ch 4, 5, 6, 9, 10 (pp 169–174).

Frontispiece

THE OLD SLATER MILL AT PAWTUCKET, R. I. AS IT APPEARED IN 1850. THE INSET SHOWS IT AS IT APPEARED ORIGINALLY IN 1793. FROM FIELD'S HISTORY OF RHODE ISLAND. (*See Article 13.*)

PRINCIPLES

OF

INDUSTRIAL ORGANIZATION

BY

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PREFACE.

As industrial enterprises have grown in magnitude, as processes have become more refined and competition more keen the problems of organization have steadily grown in importance. Just as the tools and processes of our forefathers became inadequate as enterprises grew in magnitude, so the simple administrative methods formerly in use have long since been outgrown by modern plants. Aside, however, from these reasons there are other factors affecting organization, which, while of little importance in former times, promise to be of great importance in the organizations of the future.

The ideals that man has held before him in his toilsome journey from savagery to civilization have varied with changing time and place. Among many of the older nations war was the central thought, the country was an armed camp and predatory methods were an approved means of national support. In other cases some form of religion was the predominating influence, and the social and industrial organization was modelled accordingly. In a few of the older civilizations industry was held in high esteem; but for the most part it was considered menial to labor and industry was adjudged by standards that now seem strange indeed.

But as the humanistic side of civilization has made progress we have attained higher ideals regarding industry. Never before in the history of mankind has it been so universally acknowledged that physical, mental and moral well-being rest upon and are solely supported by labor. Industry is the *business* of the civilized world, and the greater part of our problems, national, state and home, center around the great industrial questions. Furthermore, industry is being looked upon more and more, not as an incidental matter, nor merely as a means of securing personal profits, but as the great basic feature of our civilization on which must rest our entire well-being.

And with this new evaluation of industry has come new and higher ideals regarding service to humanity. No longer is it

considered necessary merely to *tell* people how to improve themselves mentally, morally and materially, but there is a cry for a remodelling of our industrial structure that will put the material basis, on which these improvements rest, into the hands of all.

It is for these reasons that the ideas embodied in so-called scientific management are coming in for such close scrutiny. Changes of a similar character and as far reaching in their effects have been made in our industrial methods in times past with little or no comment from any quarter. But to-day changes of this character cannot be made, as formerly, on the basis or plea of *increased production* alone. The spectre of *distribution of profit,* the bugbear of our industrial system stands constantly in the background, and the question that it ever raises — What will be the effect of these changes on humanity? — can no longer be ignored.

An intelligent appreciation of even the simpler problems of factory organization and operation cannot be attained without some knowledge of the origin and trend of these modifying factors. Already the effects of many of them are rapidly passing from the transitory stage of public sentiment into the more permanent form of state or national legislation. This is the writer's excuse, if any is needed, for the first four chapters of the book. It is not the purpose of the book to exploit any form of industrial management or any specific remedy for industrial evils, but it is an endeavor to set before young men entering the industrial field the salient facts regarding the most important movements with which they are sure to be brought into contact, and to explain the origin and growth of the important features of industrial organization.

To the engineer whose ever widening circle of usefulness brings him more and more in contact with economic problems these are matters of peculiar importance, and it is for the needs of young engineers primarily that the book has been written, being based on a course of lectures given by the writer for a number of years past to the senior class in Sibley College of Mechanical Engineering, Cornell University. It is hoped, however, that the practicing engineer or manager who wishes to know something of the fundamental principles of organization, without regard to some specific system of management, may also find it of interest.

It has been the writer's endeavor to deal as far as possible

with general principles only, and no effort has been made to illustrate the many kinds of cards and forms used in industrial management; only such cards and forms having been shown as were necessary to illustrate the principles discussed. These documents are so varied in character that they possess little educational value except as they illustrate principles, though instruction in this subject is greatly aided by collections of the cards and forms used in representative systems of management. Such documents, also, grow naturally out of the needs of the business concerned, and the form or blank that is best for one industry may be entirely unsuited for the same purpose in another. If the need is clearly defined there is usually no trouble in making a card or form that will be exactly suited to the work, though the practical man can, of course, obtain help and suggestions from collections of such documents.

The writer has availed himself freely of the works of other writers, and has endeavored to give full credit for this assistance where such help has been used. The subject matter is necessarily much condensed, but ample references have been included to provide collateral reading. In fact any book that would do full justice to this great subject would be many times too large for the purpose for which this work is intended.

The writer is greatly indebted to Mr. John H. Barr, Consulting Engineer for the Remington Typewriter Co., Mr. F. P. Halsey, Editor Emeritus of the American Machinist, Mr. L. P. Alford, Editor of the American Machinist, Mr. E. E. Barney, Superintendent of the Remington Typewriter Works, Mr. F. R. Whittlesey of the General Electric Co. and Professors A. E. Wells, C. D. Albert and John Bauer of Cornell University for assistance in reading the manuscript and for helpful criticisms. The author will be grateful for suggestions or criticisms that will make the book more useful, or for corrections that will make it more accurate.

DEXTER S. KIMBALL.

ITHACA, N. Y.
September, 1913.

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CHAPTER I.

FUNDAMENTAL AND HISTORICAL.

1. Fundamental Principles. The *total* wealth that any people can create is governed primarily by two factors:

(1) The natural resources of the country that they inhabit.

(2) The tools of production, mental and physical, which they possess for developing these resources.

Thus, savages living in a rich and fertile territory do not rise above the level permitted by their tools of production while nations, such as Germany, with comparatively small resources may easily occupy a foremost position among civilized peoples because of their highly developed industrial processes. The progress of civilization, in fact, is measured by the character of the tools which man has developed; and in a general way we recognize this when we speak of the Stone Age, the Bronze Age, the Age of Iron, and the Age of Steel. It is not unbelievable that we shall yet develop another metallic basis which shall serve as an index for a higher plane of civilization.

The *average* wealth, and consequent average physical comfort and mental development, which any people can enjoy is governed, for given natural resources and given productive powers, by the *industrial system* under which production is carried on; and the industrial system is in all cases closely interwoven with the ideals of the ruling classes and the organization of society. In the ancient Egyptian and Babylonian civilizations, for instance, the tools of production were so primitive that the output per individual was very small even with great natural advantages. As a consequence, when each individual producer had contrib-

uted his share toward the support of the necessities of a civilized state, there was little left for him or his family and the average well-being was very low. It may be taken as axiomatic that in any civilized community the state of the actual worker approaches that of slavery as his tools are more and more primitive even though the upper or non-producing classes may enjoy a very high state of mental development and physical comfort. The older nations were of necessity, therefore, supported by vast numbers of low-paid producers whose state bordered on, or actually was, that of slavery; but one can readily conceive of civilizations possessing the highest type of tools and operating them by slave labor. *Highly developed tools of production make possible a high average state of mental development and physical comfort; but the realization of this average depends on national ideals and the social and industrial organization by which the wealth produced is distributed.* Now, naturally, the modern nations that have made the greatest advances industrially have also acquired the highest national ideals; and it is in these we find an ever-increasing tendency to inquire carefully into the social effects of all industrial methods, new or old, with the view of attaining the highest possible degree of general comfort and enlightenment.

It is obvious that, in general, for a given result, the skill of the worker must be increasingly great as his tools become decreasingly primitive and ineffective. We are accustomed to speak of production with primitive tools and high manual skill as **handicraft.** It is to be noted, however, that skill of hand may be necessary even with very refined tools as in the operation of some of our metal-working machines. Usually the term handicraft is interpreted as synonymous with *hand tools* but even in very ancient times machines such as looms were in use though their operation required skill of hand. In general, however, even such machines were within the reach of all and industry under a handicraft system is essentially *individual* and not dependent upon *congregated* effort.

2. Factory System. By the term **manufacturing** we usually refer to the production of goods by means of **congregated labor**

and the use of **machinery**. These characteristics are not, however, distinctive of modern methods as both can be and were used[1] by handicraftsmen before the modern era of production began. The Egyptians and Romans were well aware of the advantage of congregated labor, and machinery was in use in England and on the Continent before the birth of modern methods. Nor does the principle of **division of labor** explain the difference between old and new methods, though some modern writers have fallen into the error of this assumption. Division of labor is as old as humanity; it is an essential feature of civilization and was used in some detail by the old handicraftsman. The new methods have enabled us to utilize more fully the advantages of congregated labor and division of labor, but these are not the essential features of the change, which will be discussed more fully later on. Handicraft does, however, carry with it the idea of a limited output because of the primitive nature of the tools employed, while manufacturing is essentially synonymous with production in quantity. Handicraft, moreover, carries with it the idea of a *permanent* state of tools and production, and a consequent permanent social structure. Manufacturing, on the other hand, is synonymous with rapid change in productive methods and consequent change in the social and economical conditions.

By the term **factory system** we refer particularly to the modern method by which men organize labor and tools for the production of commodities. There have been other forms of industrial organization, however, which have varied greatly with changing time and place. Previous to about one hundred and fifty years ago, all productive organization of which we have any record was based on handicraft. In most instances the organization was extremely simple, because handicraft is essentially individual. The Egyptians, however, had factories such as that at Canopus where pottery was manufactured, and the Romans had a well-organized system of factories for the making of armor. Factories of considerable size also existed in

[1] See Modern Factory System, by W. Cooke Taylor, p. 3. See also History of the Factory System, by W. Cooke Taylor.

England and on the continent during the Middle Ages.[1] These factories, while possessing the characteristics of congregated labor and perhaps in many instances including machines, were, after all, simple collections of handicraft processes with some division of labor. They were not comparable with modern factories so far as the systematic organization of labor or of processes is concerned.

3. National Ideals. It is to be especially noted that national ideals, popular opinion or some similar influence has always greatly influenced industrial organization. Thus, in India the caste system for countless years prohibited all forms of factories and all production was by simple handicraft, definite kinds of work being assigned to particular classes of people. Under the Roman system the Armorers or Fabrica were a class of artisans set apart for this sole purpose and they could not change their calling. It was a form of state-supported and regulated slavery. History abounds with similar instances of the effect of public opinion or national necessity upon the method by which the nation was provided with the necessities of life. While, therefore, the essential features of our modern system will probably continue indefinitely, it need not be a matter of surprise or alarm that many changes and regulations have been made and will be made in deference to public opinion or national necessity.

4. Systems Preceding Present Methods. Our present industrial methods originated in England during the latter part of the eighteenth century and it is important to understand the industrial methods in use there just preceding the change to modern methods. Under the Feudal System of the Middle Ages men were either bound to the landed proprietors of the soil or, if independent craftsmen, they were held together by the strong bonds of Trade Guilds (the ancient Trades Unions). These influences while hampering the personal freedom of the workman also protected him in a measure against the oppression of influences external to his calling or surroundings. With the decline of the Feudal System, and the growth of personal liberty, these restraining and protective influences gradually disappeared.

[1] See The History of the Factory System, by W. Cooke Taylor.

There was also an ever-increasing tendency to pay dues and reward labor, not by labor or by the direct product of labor, but in money; and long before the rise of the modern system of production this had resulted in a considerable wage-earning class. It is to be specially noted, that this wage-earning class, while free to sell their labor as they pleased, were totally unprotected either by law or by mutual organizations of any kind such as had formerly existed or have since come into existence.

Industry had not as yet assumed a definite form, but was passing through a transitional stage in which there existed three clearly defined methods of production. First, there was the ancient method of isolated handicraft which had existed from earliest times. This form of labor had just been rendered unorganized and free from restraint or protection by the downfall of Feudal influences. In this method the producing unit was (and still is, for the system still survives in a feeble way) the workman himself, and he and his family were dependent solely on his efforts.

Second, there was what has been called the Domestic System which, as can readily be seen, grew directly out of the decay of the Feudal System. In this form of industry the householder was primarily an agriculturist and he and his family tilled their small farm. At such times, however, as he, or any member of his family, was not so engaged they practiced some handicraft calling as weaving, or spinning; implements for which were installed in some part of his house, and were his own property. He might even hire assistance for either or both of his activities, and the product of his spinning wheels or looms, in excess of what was needed at home, was disposed of to dealers. This system was a very natural outgrowth of the changed conditions, and was the most important method of production just previous to the great change.

The third form of industrial organization then existing was the forerunner of our modern factory system. In this method the production was carried on by a controlling owner, or principal, who hired employees to operate machines or furnish hand labor in exchange for wages. The fact that the industry was usually

carried on in the employer's house does not alter the fact that these establishments were *factories* in the full sense. We have well-authenticated records of some of these old factories, as for instance, that of "Jack of Newbury"[1] whose works employed over one thousand persons. This form of industry grew up by the side of the Domestic System and perhaps grew out of a natural extension of that system. It is not to be confused, however, with its successor, the modern factory system. True, it had many of the defects of the modern system, and we find ample record of legislation aimed at the oppressive methods of master cloth makers before the present era. It is possible that in time this system would have supplanted the Domestic System entirely in all forms of manufacturing industry with consequent increased discontent of the masses and capitalistic troubles similar to those we now have.

The condition of the common people just previous to the great change to be discussed should also be carefully noted. Economic conditions were such that they found a ready market for their output, the demand exceeding the supply and hence they were prosperous. They enjoyed a large measure of personal freedom and independence, the tools of production being more easily obtainable than at present. These apparently satisfactory conditions have been much exaggerated in making comparisons with present-day conditions. Many writers and poets[2] have written and sung of this so-called "Golden Age" as one of pastoral delight and content. As a matter of fact and history the condition of the common working people, viewed from a present-day standpoint, was wretched indeed. Housed[3] in unsanitary hovels, uneducated and loose in morals, a prey to epidemics and plagues, their condition would be envied by few workmen to-day. Whatever evils the modern factory system has brought in its train, it must be credited with making possible a vast improvement in the workers' environment. It cannot be said, however, that it has always improved the workers' bodily vigor; but this

[1] See Modern Factory System, by Whatley Cooke Taylor, p. 49.

[2] See The Deserted Village, by Oliver Goldsmith.

[3] See The Factory System of the United States, by Carroll D. Wright in Report of the Manufacturers of the United States at the 10th Census.

has not been the fault of the system so much as it has been due to the ignorance and greed of those controlling it.

It is not likely, however, that these changes could ever have come about to a degree comparable with modern conditions since these old factories were based on *handicraft*, the limitations of which we have already discussed. Nevertheless, enough experience was had with handicraft factories to show that certain social changes, for which our modern factory system is wholly blamed, were even then under way and that they are an integral part of the change from the state where agriculture was the principal occupation with manufacturing industry a subsidiary matter, to one where these two great branches are entirely divorced and manufacturing is carried on as a separate venture with congregated labor, a wage-earning class and capitalistic support and control.

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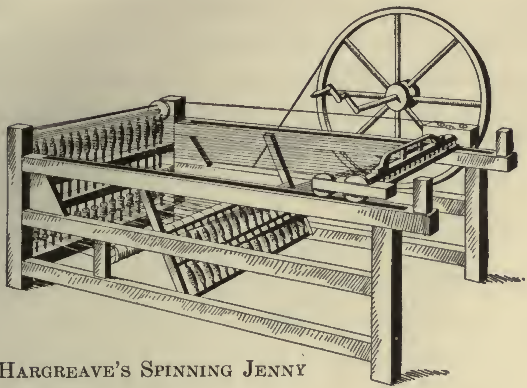
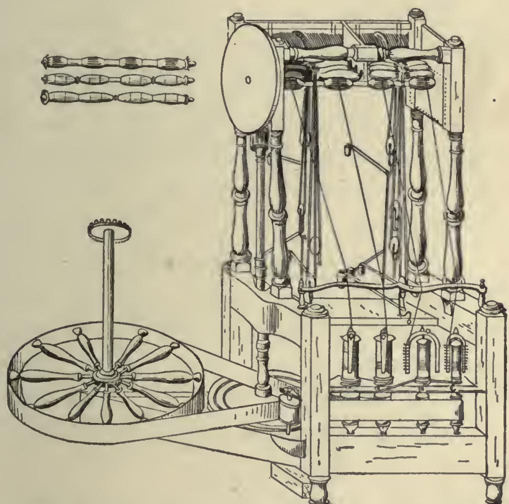
CHAPTER II.

THE INDUSTRIAL REVOLUTION.

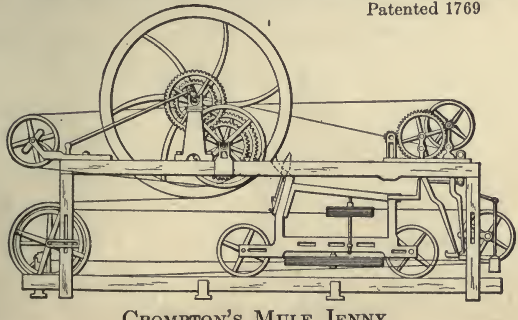
5. The Great Inventions. The industrial conditions described in the preceding chapter prevailed in England, and for that matter in many parts of Continental Europe, up to about the middle of the eighteenth century. It is a somewhat remarkable fact that mankind had dwelt on the earth in a civilized state so long and had yet made such a very small advance in industrial methods. The great callings were agriculture and the textile industries and in both of these the implements were exceedingly primitive, most of them having changed but little in countless thousands of years though in use (and still in use for that matter) by all civilized and by many semi-civilized nations. About this time (1750), however, there began a simultaneous movement in England and on the Continent looking toward the improvement of the implements of spinning and weaving. It is difficult to fix exact dates or even to give proper credit for the early conceptions of these improvements. Undoubtedly, many men had independently stumbled upon or thought out these new methods but had been unable to develop them into practical operating machines. In England a great incentive was given to invention by the offer of the government, of prizes of 50 and 25 pounds respectively for the first and next best improved method of spinning. The government's interest lay in the fact that the policy of foreign expansion, then under way, made it very desirable to secure more textiles for export, and the weak part of the industry was the spinning, which was then done on the primitive wheel. The many unsuccessful efforts to improve spinning and weaving culminated in the latter part of the century in what are usually known as the "Four Great Inventions." In 1770 James Hargreaves, a weaver, patented the "spinning-jenny," which consisted of a frame with a number of spindles side by side so that many threads could be spun at once. In 1771



HARGREAVE'S SPINNING JENNY



SIR RICHARD ARKWRIGHT'S SPINNING MACHINE
Patented 1769



CROMPTON'S MULE JENNY

Richard Arkwright, originally a barber, operated a mill in which he successfully used his " water-frame," so-called because it was driven by water power, and the term " water-twist," as the name of the product, still survives. In 1779 both these inventions were superseded by the invention of the " Mule " by Samuel Crompton, a spinner, whose machine combined all the good features of his predecessors and was so-called as being a hybrid offspring of these former inventions. Finally, the invention of the power loom in 1785, by Dr. Edmund Cartwright, a Kentish parson, gave to the weaving industry what these other other inventions had given to the spinning industry.

These inventions, of themselves, in time would have revolutionized the textile industry; but the process was greatly hastened by the development of the steam engine by James Watt in 1769. This new motor gave the unlimited power and permitted the choice of location that allowed these new methods to spread with great rapidity, and the overthrow of the old methods was sudden, violent and almost complete. This very significant change in manufacturing is known as " The Industrial Revolution " and the principles involved, although first applied extensively to the textile industry, only, spread with amazing rapidity to all kinds of industry changing and stimulating them to a very remarkable degree.

6. The Character of these Inventions. Viewed from the standpoint of modern machine construction these new machines were neither complex nor efficient, and their great importance lies in the application of the principles they involved. These principles are, as a rule, not well understood and are often confused with other phenomena incident to the change. For instance, this change is often spoken of as a change to *machine industry*. Now, as we have seen, machines were in use in the textile industry preceding the great inventions, and factories and factory systems of manufacture had already appeared. Nor is the extension of the principle of *division of labor* the fundamental change but rather a corollary of the new methods. The real change in manufacturing methods can perhaps be best studied by taking a simple fundamental case as follows:

Suppose it be desired to drill four holes *h, h, h, h* in a number of plates like *A*, Fig. 1, so that they bear a certain fixed relation to the edges of the plate; and suppose the operator to be equipped with the ordinary drilling machine which guides the drill so that it pierces the plate squarely. To drill these holes in *one* plate, with any degree of accuracy, requires a high degree of

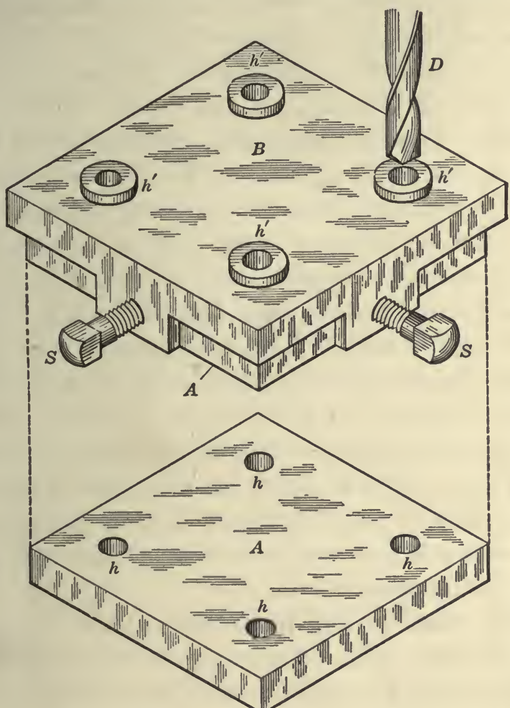


FIG. 1.

skill on the part of the operator; and to drill any number of such plates so that the spacing of the holes in them will correspond closely with those in the first plate requires a very high degree of manual skill, considerable time per plate, and is a costly operation.

Suppose, however, a skilled workman makes a so-called "drilling jig" (*B*, Fig. 1) in which the plate *A* can be securely clamped by set-screws *S* and in which all the plates can in turn

be clamped in exactly the same position. The plate B contains four holes h', h', h', h', which have been very carefully located to correspond with the required location of the holes in A and when A is held in B these holes h', h', h', h' are directly above the required location of holes h, h, h, h. The holes in B are surrounded by hardened steel rings or "bushings," so-called, to prevent the drill D from unduly wearing them and D fits the holes in these bushings accurately and closely.

Now, it is evident that almost any *unskilled* person can drill the plate A, when held in B, as accurately as the most skilled workman can without it. Further, he cannot drill the plate *inaccurately* if B is accurately made. True, he must have a slight amount of training in handling the drilling machine, but this is small and soon acquired. *The accuracy of the work no longer depends on the skill of the operator but on the accuracy of his tools.*

The principle illustrated above has been aptly called "The Transfer of Skill"[1] and it is to be especially noted that this principle has nothing to do with division of labor, though as can be seen it allows an extension of the same. Nor is the principle inherently applicable to *machines* alone; it can be and is applied to hand methods. True, most machines are constructed with this end in view, the drilling machine mentioned above, for instance, having this characteristic in so far as guiding the drill vertically is concerned.

It is evident that for a given operation the more skill that is transferred to the machine the less is required in the operator. When nearly all the skill has been so transferred, but the machine still requires an attendant, it is called a **semi-automatic** machine. Turret lathes are excellent examples of this class of machinery.

In drilling the plate A without the jig the skilled mechanic must expend *thought* as well as skill in properly locating the holes. The unskilled operator need expend no thought regarding the location of the holes. That part of the mental labor has been done once for all by the toolmaker. It appears, therefore,

[1] Strictly speaking the term "skill" refers to either mental or manual ability. It has seemed expedient here to use it in the more commonly accepted sense of skill of hand.

that a "**transfer of thought**[1] or **intelligence**" can also be made from a person to a machine. If the quantity of parts to be made is sufficiently large to justify the expenditure it is possible to make machines to which all the required skill and thought have been transferred and the machine does not require even an attendant. Such machines are known as **full automatic machines.** Automatic screw machines are excellent examples of a complete transfer of skill and thought. Care should be taken to distinguish clearly between *transmission* of intelligence, as illustrated in drawings, specifications and written or spoken communication, in general, between *men* and the transfer of intelligence or thought from a skilled man to a *machine.* These principles, transfer of skill and transfer of thought, lie at the bottom of modern industrial methods. Under former and simpler methods of manufacture the machine was an aid to the worker's skill, the amount of skill that had been transferred being very small. In the new machines the transfer of skill and thought may be so great that little or none of these are required of the attendant worker.

7. Extension of these Principles. As before noted it is difficult to ascribe exact credit for these improvements. They assumed great importance first in the textile industries, since these were the most important manufacturing interests in England at that time. But similar changes took place either simultaneously or shortly after in all lines of work, especially in the metal-working industries. In a series of articles in the Engineering Magazine for 1899 Henry Roland gives a very interesting and instructive account of the rise of these principles in machine tools in which he credits Samuel Bentham with first fully comprehending the full significance of the toolmakers' art about 1791. The slide rest for accurately guiding cutting tools, invented by Henry Maudslay of England, the turret, invented by Henry Stone of New Hampshire, and the combination of these two elements into the automatic lathe by Christopher

[1] The modern player-piano is an excellent example of transfer of skill and thought. The thought of the composer is transferred quite accurately but the transfer of playing skill is imperfect. Note that composing and playing are not necessarily the accomplishments of any one man.

Miner Spencer of Connecticut were the great epoch-making improvements in machine construction. Perhaps invention is not the correct term to use as, no doubt, all of these elements had been thought of long before by other men; but to these men at least belongs the credit of making them working possibilities. These three elements, namely, the slide rest, the turret and Spencer's " brain " or cam wheel for operating the combination of the first two are perhaps more used in complex automatic machinery than any other machine elements.

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CHAPTER III.

THE EFFECTS OF THE GREAT INVENTIONS.

8. Separation of the Worker from the Tools of Industry. The effects of the great inventions were many and far-reaching as well as complex. A consideration of the most important of these is necessary to a full understanding of modern conditions. The first, and one of the most significant effects, was to separate the worker from ownership of the tools of industry. No longer was it possible for almost anyone to secure the implements of his trade. *Capital* was now required both to build these new implements and to provide power to operate them. The new methods, therefore, hastened the change foreshadowed by the old handicraft factories, where the industry was supported and controlled by capital and the worker was a wage earner pure and simple and unsupported by an auxiliary industry such as agriculture.

9. Degradation of Labor. Following closely on the above evolution the textile worker found that the skill which he had already acquired was useless as a marketable product since the new machines could be operated by unskilled workmen, in many cases young boys and girls being sufficiently strong and intelligent. In some cases, in fact, his handicraft trade soon ceased to be an industrial factor so radical was the change in method. Since industry was limited, and furthermore, since it is difficult for a mechanic to change his calling, practically the entire textile producing population was **degraded**; that is the market value of their labor was reduced to that of the unskilled girls and boys who could operate the new machines. This so-called **degradation of labor** is one of the first results of the introduction of labor-saving machinery. In the beginning its effect was much more marked than at any time since, because almost the entire industrial field, which was limited, was almost instantly affected.

As will appear, all classes of men are benefited, in the long run, by methods that multiply productive power; but these beneficial effects often affect others outside of the industry in which the change is made at the expense of those directly concerned, and for this reason the worker is naturally opposed to the introduction of labor-saving machinery that directly affects his calling.

10. The Extension of the Field of Labor. The new methods of production have enabled many unskilled people to take an important part in many industrial fields formerly occupied solely by skilled workers. To-day in nearly every large manufacturing industry the unskilled or semi-skilled labor greatly outnumbers the skilled, and product of great accuracy and high finish is turned out by such organizations. This principle of **extension of the field of labor** is a broad one. As more and more skill and thought have been transferred to hand and machine tools it has become increasingly easy for men and women to take part in what was formerly entirely skilled industry. The *actual* production of shoes, watches, typewriters, etc., is conducted almost entirely by semi-skilled labor.

This influence has not been confined to industries that already existed but has made possible the existence of many new industries. The telephone, the sewing machine and countless other articles now considered necessities of daily life are obtainable by the majority of people solely because the new methods of production have multiplied and cheapened production, the demand for these articles opening up new fields of manufacturing with consequent farther extension of the field of labor.

11. The Elevation of Labor. While the introduction of these new methods may degrade certain classes of labor they may, on the other hand, **elevate** others. The skilled mechanic that has been engaged in drilling the plate in Fig. 1 is not necessarily degraded by the introduction of the drilling jig, because his skill can be utilized to *make* such tools; and this class of labor, namely, the skilled workers in the metal trades, has, on the whole, usually been benefited rather than otherwise, by the new methods, though at times trying periods of readjustment have

ensued upon the introduction of labor-saving machinery into their own industry.

Again the unskilled worker who is taken from low-paid menial employment and taught to operate a semi-automatic machine can usually earn more money than formerly and be elevated to a higher plane. The history of manufacturing in New England shows very clearly the absorption into the manufacturing industries of the successive waves of immigration of unskilled labor that have from time to time moved into these states.

12. Increased Production and Decreased Cost. Manifestly these new methods have multiplied man's productive power many fold, enabling him to produce more per unit of time, with a corresponding reduction in the cost of production. This feature, and the principles of elevation of labor and extension of the field of labor more than compensate in the long run for the effects of degradation of labor, though as before noted the many benefit at the expense of the few. Human progress apparently cannot take place without someone suffering. *Theoretically* all should be greatly benefited by these improved methods, and the reason why such has not always been the case is not because of the processes themselves, but because their net result is to *increase* production solely. They do not carry with them inherently any influences tending to rearrange the *distribution* of the increased profits derived from them, nor to offset the effects of the fierce competition rendered possible because of this increase in productive capacity. Invention and its result always act quickly; social and political changes move more slowly. The natural law of supply and demand operated quickly under the older and simpler methods. The complexity of modern methods tends to make these laws act much more sluggishly. It is only after a struggle lasting over a hundred years that there is hope, even, of instituting reforms that will in a measure restore equilibrium of distributive methods so badly distorted by the results of the great inventions.

13. Immediate Results of the Industrial Revolution. It will be remembered that at the time of this great industrial change the laborer was unprotected by either legal statutes or mutual

protective societies of any kind. The first effect of the new methods, therefore, was a heartless enforcement of the first two principles enumerated above, the worker being suddenly torn from the tools of production and degradation of labor of the worst kind resulting. No slavery that ever existed could have been worse than that into which the textile workers of England were quickly thrown, and it is difficult, even allowing for the hard spirit of the times, to account for the atrocities inflicted upon them by those into whose hands the control of industry fell. An account of these inflictions is out of place in this treatise but the history of the change should be carefully read and pondered by every man before expressing too positive an opinion regarding labor matters. Some little extenuation is offered[1] for the reason why the government and the better classes allowed this free "exploitation of labor," in the situation in which England was placed at that time. First, she was continually engaged in foreign wars which not only occupied the attention of the ruling class but made necessary large sums of money which were more readily available under the new methods. Second, but no less important, were the peculiar views on political economy then in vogue.

Darwin's law of the "Survival of the Fittest" and the Malthusian doctrine of over-population seems to have made a deep impression on the existing national ideals. It was the day of "laissez-faire" and people apparently believed that these things were necessarily so, or if curable they would cure themselves if let alone.

The British government was quick to see the great commercial advantage of the new machines and stringent laws were passed prohibiting the exportation of machines or drawings to the British colonies or foreign countries. Several attempts were made in America, however, to establish the new methods, but with indifferent success till Samuel Slater, a young Englishman, who had worked for Strutt, a former partner of Arkwright, built in 1790 some Arkwright spinning machines for the firm of

[1] See The Factory System and Factory Acts, by R. W. Cooke Taylor. See also Modern Factory System, by R. W. Cooke Taylor, Chapters 6 and 7.

Almy and Brown of Pawtucket, Rhode Island. These machines operated 72 spindles and were housed in the building shown in the frontispiece. While other spinning machines were built at about the same time, the success of the Slater mill was so pronounced that it has usually been taken as marking the introduction of the new factory system into this country, and Slater has been called "the father of American manufactures." The first mill[1] in the world wherein textiles were produced from the raw material under one roof was built in Waltham in 1814.

The evil effects of the new system were never as bad in America as in England, for obvious reasons. The freedom of a new country and the temper of the people were both opposed to such a state of affairs; and before the arrival of large numbers of helpless aliens, labor legislation had come to the rescue and the beneficial effects of the new methods enumerated above began to be felt. Nevertheless as the older states become more and more thickly populated the evil effects become more pressing and the highest of statesmanship will be needed to show a way out of these difficulties if the system is to remain and fair and equitable distribution of its advantages is to be instituted.

The above influences and effects are, of course, not so marked as formerly, partly because the industrial field is much larger and hence not so easily disturbed; but they still are, and must always remain, characteristic features of transfer of skill and transfer of thought, and must alway be reckoned with in judging the effects of labor-saving machines or processes.

The establishment and growth of the new factory system were greatly hastened by the changes wrought in methods of transportation brought about by the introduction of steam power. Obviously the new power-driven spinning and weaving machines had to be grouped close to the source of power. In the beginning water power was the only source available, but as steam power came into use the location of factories was not so restricted. With improved means of transportation the congregation of men and machines was not only rendered econom-

[1] See The Industrial Evolution of the United States, by Carroll D. Wright, p. 131.

ically possible but to the increased efficiency of productive methods was added much more effective means of distributing the product. Local competition of handicraftsmen, at a distance from the factory that would have protected them under the old methods of transportation, was thus obliterated. Improvements in methods of transportation have kept pace with improvement in productive processes, since the new productive methods themselves were soon applied to the making of machinery of transportation.

To these influences have been added those of the telegraph and telephone and other improved methods of communication. These are commercial possibilities, and of almost universal use and convenience, solely because of modern productive methods. Improvements in facilities for transportation or communicating intelligence, therefore, aid productive processes and these in turn make transportation and communication more efficient, the entire system of production and distribution constituting a most remarkable development unlike anything that has ever gone before.

CHAPTER IV.

CORRECTIVE INFLUENCES.

14. General. As might be expected the direful conditions resulting immediately from the Industrial Revolution brought into life various reactive movements looking to their reform and toward fairer methods of distributing the increased wealth that was created. Some of these movements, such as the Trades Unions, are revivals of organizations that had formerly existed and had disappeared because of lack of economic necessity for existence. Others, such as Socialism, are more strictly political in their character and have not, as yet, affected industrial organization directly, though exercising great modifying effect indirectly through other channels. These last influences lie outside of the scope of this discussion.

Of those that do touch industrial organization intimately and directly and that constantly tend to modify factory methods and conditions the following are perhaps the most important.

(1) Factory Welfare Work.

(2) Factory Legislation.

(3) Labor Unionism.

(4) The Arts and Crafts Movement.

(5) Industrial Education.

Only the briefest account of the salient features of these movements can be given here. Reference is made to them solely to call the attention of the student to the fact that they are integral factors in our industrial system. They are very closely related to factory management, and their causes and probable effects should be carefully studied. Like all other phenomona there are definite causes for their existence and they will grow or abate as these causes persist or are removed.

15. Factory Welfare Work. Under this title is included all efforts of employers and private individuals, in general, that are

directed toward the betterment of their employees, physically, mentally and morally. The movement is virtually a recognition that the employing or capitalistic class, as a whole, owes a duty to the employed class over and above that prescribed by law; and that the employer's whole duty is not defined by the agreement regarding wages. While essentially private and individual in its character the movement has, no doubt, been a powerful furtherer of industrial legislation which, after all, is simply an expression of the will of the community and the two are closely connected.

Welfare work owes its origin largely to the work of Robert Owen who in 1800 at the age of 28 became managing owner of the New Lanark Mills about twenty miles from Glasgow. The village contained about 1300 people in families and between 400 and 500 pauper children between five and ten years of age. These children were "parish apprentices," that is children from the poor houses placed in the mill village under agreement with the pauper overseers. Practically the only law governing these people was the will of the manager.

Owen himself has recorded the conditions that he found at New Lanark. He says[1] "The people lived almost without control in habits of vice, poverty, idleness, debt and destitution." The state of the pauper children, many of them mere babies, was particularly distressing. When it is considered that this was conceded to be the best managed mill village in the kingdom one wonders what the others were like, and, indeed, it is difficult to believe the many well-authenticated accounts of the dire straits into which the manufacturing population had fallen by reason of the unrestricted application of the new methods.

Owen[2] had long pondered a plan for improving such conditions and now had an opportunity for putting his theories in effect. Against great difficulty, *including opposition from the employees themselves,* he gradually built up a model village the equal of which did not exist and has seldom if ever been seen

[1] See Robert Owen and his Social Philosophy, p. 27.

[2] The story of this model village and the point of view of this great reformer will repay reading. See Life of Robt. Owen, by Lloyd Jones, and also Robt. Owen and his Philosophy, by W. L. Sargent.

elsewhere. His reforms included improved sanitation in homes and factory, recreative facilities, library and schools, methods of purchasing supplies for the workmen at low rates in such a way that they would not be cheated, elimination of drunkenness and the reduction of the working day to ten hours, thirteen and fourteen or even sixteen hours being the length of the working day elsewhere. He, in fact, anticipated practically every item of welfare work that has been attempted since.

Owen carried on this work through good times and bad times, at one time paying full wages for four months, during which the mills were idle, at a cost of $35,000. But in spite of what, to his partners and many others, seemed an extravagant and useless outlay of money the business prospered and paid handsomely, the village becoming a model of its kind.

Differences with his partners compelled his retirement from the partnership and the village relapsed into its old state. Owen took up other activities looking toward legal protection of factory employees and to promulgating his theories of industrial organization. These theories, frankly socialistic, have not and probably will not be realized but, nevertheless, the world is deeply indebted to this fearless reformer, philosopher, philanthropist and manufacturer.

The ideas that he introduced at New Lanark were not followed to any extent until a few years ago when they were revived, particularly in America. The work has, in general, been conducted closely along the lines of Owen's experiment and in some instances great sums of money have been expended by single individuals or companies in this work.

Curious as it may seem at first sight, some of the most pretentious efforts along this line have resulted in disastrous failure. It is pertinent, therefore, to examine the basis on which this work may be successfully conducted. It must be borne in mind that the workman of to-day is vastly different from those of Owen's time, and that the good will of his employees, backed by public opinion and similar influences, make it increasingly necessary that the employer be able to *justify* expenditures of this character. Sanitation, ventilation and safe and comfortable

surroundings are easily justified and pay good dividends on the money expended to obtain them. The danger usually lies in *overdoing*, as where a factory is equipped with elaborate lavatories and swimming tanks when the employees cannot afford a tin bath tub at home. It is clearly the privilege and duty of the employer to do what he can to elevate the moral tone of his establishment but efforts along this line must be very *general* and must not disturb educational or religious ideas that are strictly *individual* or *communal*. Even efforts looking toward financial betterment must be very clear-cut and definite to be successful, though perhaps this kind of welfare work is most needed, especially if accompanied by *financial education*.

More important still is the spirit that animates the employer in starting welfare work. If the object be advertising or distraction of the employee from other phases of the factory life nothing but failure can follow, as experience has shown. Even when the employer's intention is of the best, nothing which savors of *patronage*[1] may be expected to succeed. Each factory is a problem by itself and none is so small as to prohibit something of this kind being successfully undertaken if undertaken in the right spirit, and with due regard to modern conditions of the industrial field and the intelligence of the workman.

References :

Social Engineering, by W. H. Tolman.
Experiments in Industrial Organization, by Edward Cadbury.

16. Industrial Legislation. Industrial legislation, contrary to popular opinion, is far from being a new issue. History[2] in all ages abounds with instances of the legal regulations of industry and in many countries the same effect has been obtained by custom or caste. Nor has industrial legislation always been enacted in favor of the workman, but sometimes it has been aimed *against* him when economic causes gave him the upper hand, as instanced in the Statute of Laborers[3] of the year 1349.

[1] In a recent strike against a company that has done a great amount of welfare work the slogan of the strikers was "more pay and less charity."

[2] See The Law of Hammurabi.

[3] See The Factory System and the Factory Acts, by W. Cooke Taylor, p. 51.

It is in fact a comparatively recent conception that the community should have little or no jurisdiction over the method of conducting industry. It so happened that at the time of the Industrial Revolution the workman was totally unprotected, legally, and the mutual protection of the old guilds had vanished. As has also been noted the attitude of the ruling class was one of *laissez-faire* and tended to exalt unduly the rights of the individual and to minimize his responsibility. The first efforts of reformers who sought legal help in rectifying the evils of the new factory towns met, therefore, with little attention, and less sympathy; and it was not until diseases[1] incident to the condition in these factory towns broke out that they obtained a hearing.

The fight for legal regulation of factories was led by such men as Robert Owen, Richard Oastler[2] and Sir Robert Peel, and the first modern Factory Act in England was passed in 1802. Its effects and that of the four succeeding acts were almost *nil* although based on the findings of commission after commission appointed to investigate these evils. Our principal source of information regarding the direful state of the manufacturing population is the evidence laid before these commissions. A brief statement, even, of the slow and discouraging growth of this movement would be out of place here, though it will repay reading. It was not until 1891 or *one hundred years after the great inventions* that a factory law was enacted in England that in any adequate way regulated some of the evils that they had unloosed.

While conditions were never quite so bad in America, industrial legislation has grown steadily as the various states have become more and more thickly populated and the problems of existence have become more and more complex. Thus the industrial legislation of the older states, such as Massachusetts or Connecticut, is voluminous and governs details of industry to a degree quite startling to one who has not inquired into it. This form of legislation is growing very rapidly, in keeping with the growing public sentiment that the state has police powers over

[1] Ibid., p. 53.

[2] See Modern Factory System, by W. Cooke Taylor, pp. 209-211.

all industry and that the community has a right to regulate the manner in which industry may be conducted in its midst, and that there is just as much need of regulating productive industry as of regulating and licensing the professional callings, such as medicine and law.

It would be useless to attempt, here, even a synopsis of the industrial laws of the various states, as they vary in character with the character of the industries of the state and the degree to which these industries have been developed. In their most highly developed form, as in Massachusetts, they exercise control over factory construction in so far as ventilation, sanitation, fire protection, etc., are concerned. They regulate the installation of machinery, such as elevators, and prescribe that care must be exercised to make all machinery safe for the workman. They also carefully regulate the hours of labor, child labor, employment of women, regularity of payment, etc., in great detail. The aim, in general, is to protect the public from the dangers of the business as a whole, and to protect the workman against the dangers of his calling. In the past they have, usually, been negative and prohibitory and were seldom *constructive* in character. This follows from the nature of their inception which is almost always the prohibiting of abuses. Of late, however, constructional legislation has appeared in considerable volume.

Evoked originally to correct certain abuses in places where *congregated* labor was a factor, they have spread with great rapidity to include nearly all forms[1] of industry. How far they will extend is difficult to predict, but recent legislation, such as some of the Employers' Liability Acts passed by some states, is very significant, and no factory owner, manager or employee can afford not to study carefully this factor in production when the new methods of intensified production and so-called scientific management are under such close scrutiny.

Industrial legislation, as has been noted, is closely connected with welfare work and may, in fact, be the result of the efforts of employers. The idea that all industrial legislation is the

[1] A few callings such as *domestic service* seem to be still without legislative regulation.

result of labor agitation is erroneous. In many instances the rights of employers and owners are specially guarded legally and in some countries labor disputes are settled by state boards of arbitration.

17. Labor Unionism. The tendency to organize is deep-rooted in human nature. Men organize for all manner of purposes, sometimes for very foolish purposes. If to this natural tendency is added the fear of a common danger this tendency is irresistible. A common danger will weld together men of all sorts of characteristics; and if the influence be strong enough the organization so formed will not reflect the characteristics of those forming it, but will reflect a *class* consciousness that buries all individual differences in the effort to attain the end sought by organizing. Labor unions, therefore, are very old human institutions. They have appeared in several forms and have disappeared when economic conditions rendered them unnecessary.

It was very natural, therefore, that labor unions should spring into existence as the result of the industrial revolution. They are a very natural result of changed industrial conditions and the time has long since passed when such movements can be suppressed by legislative action. While the history of modern trade unionism is filled with instances where they have been oppressive and even lawless they have, no doubt, rendered a great service in checking some of the natural tendencies of the new industrial system and in bettering the lot of the worker. The movement should be judged only after reading carefully the entire history of our manufacturing system. Trade unionism has suffered in times past for lack of intelligent and honest leadership. If these defects could be remedied their usefulness would be greatly increased and the prejudice now so commonly, and often justly, held against them would be greatly abated.

18. The Arts and Crafts Movement. It is obvious that the separation of the worker from his tools of production and the breaking up of the old trades by the extension of the principle of division of labor tended greatly to destroy the interest, pride and pleasure which the handicraftsman took in his work. Fac-

tory-made product is not, in general, the work of any one man but of many. The only class of worker who still retains something of the old handicraft spirit is the designer, who may yet look on the product as the creation of his own *brain*, though not of his *hands*. Furthermore, the earlier factory products of all kinds were necessarily crude and inartistic, because of the primitive nature of the first machines and also because of the lack of artistic appreciation on the part of the new class of men that came into control of industry. This lack of artistic sense was and still is reflected in the architecture and general surroundings of many factory towns. There is no doubt but that the early factory methods and surroundings dealt a hard blow at the artistic side of manufacture and affected many other phases of our life in a similar way; and before effective reformative influences came into being the spontaneous art of the old handicraftsman was dead.

The writings of William Morris,[1] the great English poet and artist-manufacturer, greatly strengthened a growing sentiment against the strict utilitarianism of our modern methods, and at present this movement, though not organized, is effecting a decided change in our manufactured products and factory surroundings, though in a somewhat different manner perhaps than some of the earlier promoters of the idea had intended.

To the earlier advocates of more artistic products and surroundings it seemed that the only effective remedy for the ultra-utilitarianism of the early days was a return to handicraft methods and surroundings, and many have advocated this remedy. Granting that such a return could be made it would not be desirable even for the purpose advocated. It must be remembered that the artistic product of the old handworker was not, in general, *for his own use*. He was fortunate indeed to get enough to eat and to drink and a hovel to shelter himself and family, and artistic furniture and surroundings were for the favored few. The great problem of the masses has not been the obtaining of artistic surroundings but the obtaining of even enough of the necessities of life to be simply *comfortable*. It is not probable

[1] See Hopes and Fears for Art and also The Aims of Art, by Wm. Morris.

that any means of increasing our productive capacity[1] will be discarded, until it is certain that the evils of the modern system cannot be limited and controlled. *Regulation* of modern productive and distributive processes and not *destruction* of them is what is needed.

For it is to be especially noted that productive industry is the foundation of man's physical and mental well-being; and art is the blossom of industry. The problem now is to build up a new industrial art suited to the new conditions. It is true, of course, that the highest forms of artistic production must necessarily always be handwork; but there is no reason why the product even of modern machine processes may not be artistic to a high degree. The limitations of the early machines no longer exist and production of any design can be made with ease and cheapness.

The great need, at present, is a general awakening of artistic appreciation in the people at large. The manufacturer naturally caters to the demands of the public and the artistic standard of manufactured goods is an indication of the taste of the buying public. The general appearance of most of our household goods is notoriously inartistic, yet, in general, all articles become more pleasing to the eye as they become better suited to the purpose for which they are intended. When it is more widely understood that *beauty of purpose* and not *decoration* is the real basis of good appearance a great change will come in the appearance of manufactured goods.

Great progress has already been made, as for instance, in the appearance of shoes, buttons, wall papers and patterned cloths and as our educational methods[2] take greater cognizance of this phase of industry still greater progress will ensue. If the benefits of our industrial methods can be equalized there is no doubt but that they will be the basis of an art equal to and vastly more widespread than any that has gone before. Even at the

[1] The failure of the natural resources such as coal and iron may in time *force* man to return to a much more primitive state than he now enjoys unless he can find substitutes for these basic features of our civilization.

[2] See Aesthetic Education by Charles DeGarmo for the modern educational viewpoint of artistic education.

present moment it is possible, because of modern methods, for the humblest to possess and enjoy artistic things in a degree never before equalled by any other similar class in the history of mankind.

19. Industrial Education. Previous to the introduction of our modern industrial methods, educational processes were limited to those needed by the clergy and the ruling class. These processes were very limited in number and were almost entirely humanistic. The rapid growth of pure and applied science stimulated by the new industrial methods quickly created a demand for men trained in a somewhat different manner as, clearly, humanistic studies did not fully prepare a man for scientific work. Hence arose the modern professional colleges of Law, Medicine, Engineering, etc.

This modification in our educational methods has not come about, however, without much debate and difference of opinion, the advocates of the older forms of education claiming that modern scientific education was no education at all, and the advocates of the new methods avering that they were as well adapted to give breadth of view as the older humanistic studies. The extremist of both sides were, as usual, wrong. All modern professional education tends more and more to require a liberal training in the humanities as a background while the purely liberal courses tend more and more to have a vocational direction.

The problem of vocational training has long been fairly well solved for that portion of the field which is fed by the colleges. As industry has grown and scientific applications have become more frequent and necessary the demand for more specialized training has extended farther and farther down our educational system till at present the schools of high school grade are rapidly adjusting themselves and there now exist, the old classical high school, the commercial high school, the manual training high school, the agricultural high school, etc., etc.

The demand for industrial education for those working at trades and in the lower ranks of industry rests upon a somewhat different basis from that which modified the upper schools. The new methods of production involving transfer of skill and a

tremendous extension of the principle of division of labor very naturally tended to break up the old handicraft trades into fragmentary parts.[1] This dissolution carried with it the old apprenticeship systems practically all of which have been swept away and the new methods are naturally antagonistic to facilities for training workers.

The manufacturer, nevertheless, must have skilled men, and to obtain them he must either establish new methods for training them in connection with his business or depend on some outside source. In his dilemma he has turned to the public school system, and the result has been a strong demand for the modification of the elementary schools along vocational lines.

On the other hand it is recognized, as never before, that physical and mental well-being and good citizenship depend on ability to make a living; and that consequently every man should be as well equipped industrially as possible. And since the new industrial conditions have made the presence of women in industry an economic necessity it follows that their preparation for life should also be carefully considered. But, as already noted, the new industrial conditions do not, naturally, provide facilities for training workers and until quite recently educational systems took little or no notice of vocational training in a specific manner. Yet experience has shown that, with industry constituted as it is at present, the upward progress of industrial workers is measured by the educational preparation they receive before entering the field. The boy or girl who enters industry with a meager education is ordinarily predestined to remain in the low paid ranks of labor and this tendency increases as labor becomes more specialized and more dependent on scientific methods. When it is considered that only twenty-five per cent of the boys and girls of this country obtain a grammar-grade education it is not difficult to understand why there is always a surplus of low paid labor and, usually, a scarcity of skilled workers.

[1] A good example is the shoemaking industry. Shoes are no longer made by *shoemakers* but by *operators* who run highly developed machines each of which does a very limited part of the work. Shoemaking as a *trade* has practically disappeared.

This broader aspect of industrial education, therefore, concerns everyone since it affects the entire life of the nation. It has already, in some states, exerted a powerful influence tending to modify the public school system and it portends in the near future not only a change in educational methods but closer state supervision of all boys and girls in the lower grades. It is a question of utmost importance.

No general solution of this problem has as yet been arrived at and the entire matter is in a very chaotic state. The following are the most important methods which are, at present, being tried out in various parts of this country:

(*a*) New forms of apprenticeship which include academic training and which usually cover a narrower range of practical work than the old systems, and do not require such a long period of apprenticeship.

(*b*) Privately endowed or supported trade schools which aim to send out men quite completely prepared to enter the industries.

(*c*) Vocational and trade schools supported by the state or city and forming an integral part of the public school system.

(*d*) "Part-time" schools in which the pupil receives his training in either a private or public school and obtains the practical part in an actual factory, mutual agreements being made between the schools and the shop so that the student alternates between the two under the direction of instructors who see that coördination of theory and practice is effected.

The kind of school best adapted to the purpose depends on the local conditions. All are good and useful in their proper place and no one of them can be said to be the *best* for all places. Fundamentally, however, there is only one kind of school whose doors are open to all comers and which is not, or at least should not be, dominated by any private interest, and that is the public school. In the writer's opinion[1] the only *general* solution of the problem that can ever be reached must, therefore, be based upon that system.

But aside from the general problem of industrial education as a means of supplying skilled workers there is a growing sen-

[1] See Industrial Education, by D. S. Kimball.

timent that it *pays* to train men for the specific needs of their calling. The old attitude on the part of the employer laid the burden of responsibility entirely on the worker. The work of Mr. H. L. Gantt[1] has called special attention to the advantages of teaching men the best way to do the work rather than to depend entirely on their native ability. Such methods cannot fail to raise the standard of production and are well worth considering.

[1] See Work Wages and Profits by H. L. Gantt.

CHAPTER V.

MODERN INDUSTRIAL TENDENCIES.

20. Definitions. The new industrial methods have greatly accelerated certain tendencies that had already manifested themselves in the old domestic factories and some of these deserve more than passing notice as they are affecting not only productive processes but our social organization as well. Perhaps the most important of these influences are those that tend toward —

(1) **Aggregation** or increase in size of industrial enterprises.
(2) **Specialization** or the limiting of the field of activity, not only of enterprises but also of men.
(3) **Standardization** or the reduction of all lines of product to a limited number of types and sizes.
(4) **Extreme division of labor,** following aggregation, specialization, and standardization and requiring special consideration.

These tendencies are all closely interlocked with each other, and with modern productive methods. It will be clearer, however, to discuss them separately before summing up their joint action.

21. Aggregation or Increase in Size. The tendency for all successful industrial enterprises to constantly increase in size is one of the most significant features of the modern industrial field. The reasons for this tendency are several fold. There are certain advantages that inherently accrue to congregated labor, centrally controlled, as against individual effort. The large factory can purchase in large quantities and hence more advantageously. As the quantity of supplies purchased increases the large factory tends continually to manufacture its own supplies from raw material, thus tending to increase its size and to control more completely the manufacture of its product. If

well managed, the fixed charges (i.e., for management, superintendence, etc.) will, in general, be less[1] than those of its smaller competitor, per unit of product. The prestige and influence of a large factory assist materially in selling its product, largely because of the apparently greater stability and permanency which it suggests. A large organization can afford to hire a better class of men especially for the higher positions of administration or design. These advantages were, no doubt, appreciated before the present industrial era by the masters of the handicraft factories, as records clearly show.

Modern industrial methods have not only magnified these natural causes of industrial growth but have added others. The handicraft system of manufacture was essentially *individual* in its character, congregated labor or factories being incidental and not essential. The very fact that the new machines were *power-driven* made it imperative that they be grouped near the prime mover, the number of machines that could be worked depending only on the power available. With the unlimited power provided by the steam engine the size of the factory and its consequent profits were limited only by the available market. The modern factory system is, therefore, essentially based[2] on *congregated* labor and the natural tendency of the large and strong to grow larger and stronger at the expense of the smaller and weaker has not, until lately at least, been held in check so far as factories are concerned, though the same tendency has been closely regulated in other human relations. Furthermore, as industry grew, undertakings became larger and more complex. The first locomotive was a mere toy compared with the three-hundred-ton Mallett compounds of our day, and industrial plants have grown in proportion.

[1] This is not always true. For instance, a large manufacturer making a wide range of product may not be able to meet the prices of a small manufacturer who is competing only in one or more lines for which he can furnish an adequate manufacturing equipment at less cost than his big competitor and with a lower fixed charge.

[2] Some critics of the modern factory system have advocated the electrical distribution of energy as a means of doing away with congregated labor and returning to individual effort. A very cursory survey of the industrial field will convince anyone of the futility of such speculation.

But there is another and very important reason for the increased size of manufacturing plants that has its origin in the *financial basis* of modern methods. This is the economy arising from the use of better tools, which, usually, are justified only with larger output. Referring to Fig. 1, suppose that it is required to drill four pieces like A and that it requires \$3 worth of skilled labor to do the work. Assume also that the cost of the jig B is \$10. Clearly it will not pay to make a jig for the four pieces. But suppose now that 500 pieces are to be made and that by using the jig a semi-skilled man, receiving \$2 per day, can drill the entire lot in five days, at a total cost of \$10. Then the cost of drilling, per piece, including the cost of the jig will be $\frac{\$10 + \$10}{500} = 4$ cents; whereas when drilled by hand the cost was $\frac{\$3.00}{4} = 75$ cents per piece. If fourteen pieces were required the cost would be about the same with or without the jig. That is, the question of whether it will pay to make tools and apply transfer of skill depends primarily on the *quantity* to be made. The greater the quantity to be made, the more complete and costly may be the tools. But the more complete the tools the cheaper becomes the product, and a decrease in the cost of the product stimulates the demand for it; and this in turn increases the number that can be made. Thus we see an ever-widening cycle limited only by the available market, and in certain lines, where the product is greatly desired by all and the cost of the material low, as in watches, the limit is practically set only by the population. Where the quantity becomes great, as in typewriters, watches, guns, shoes, etc., the advantages of the system can be realized most fully, and much of the machinery employed is of the full-automatic type involving also " transfer of intelligence. " Such manufacturing is known as " mass production."

These reasons for industrial growth are entirely aside from certain other natural tendencies which should be noted. Manufacturing industries tend *as a whole* to congregate in locations which are advantageous to the industry either because of cheap

material, cheap labor, ample supply of labor, transportation facilities or similar reasons. The tendency to organize is, as before noted, deep rooted in human nature; it is, in fact, a basic feature of civilization. It is very natural, then, that industrial interests should organize for mutual help and benefit. So on one hand appear labor unions or combinations of workers, and on the other hand manufacturer's associations, consolidations, syndicates, trusts; and all are logical results of the principles on which modern industry rests. Back of both kinds of organization there are good economic reasons for their existence; but the unreasonableness and violence often displayed by the one and the ruthless profit-wringing methods of the other have, to a large extent, obscured from public view what good elements they may possess. However, it is not likely that these organizations can be suddenly legislated out of existence. Their evil practices will disappear only as public sentiment develops against them, and regulative legislation will be effective in proportion to the growth of nation-wide ideals looking to a wise and fair use of the power which organization confers upon vast combinations of either employers or employees. The last two decades have seen a wonderful change in public sentiment towards congregated industry and its evils, particularly on the side of the employing class, and it is hoped that the world will soon outgrow and render impossible these defects as it has eliminated, it is to be hoped forever, other evils equally bad.

Specialization.

22. General Features. The underlying principle of specialization is division of labor; but the term division of labor has become associated with the individual worker, whereas specialization is, in general, far reaching in its effects, and influences industrial enterprises of all kinds. The tendency to confine the activities of an enterprise to a limited portion of the field may be seen by studying the development of any branch of manufacturing industry. Not many years ago it was common to find single machine shops producing many and varied lines of work. Engines, boilers, mining machinery, marine work and in fact

almost anything in the line of machine construction were designed and built in the same shop. As the industrial field broadened and competition became keener, manufacturers found that they could produce more cheaply by concentrating on fewer lines of work and obtaining greater quantity of product in these lines, since, as has been shown in Article 21, cost is dependent to a large extent on quantity. This tendency has been greatly hastened by the difficulty of keeping up with the progress of manufacturing in a number of lines, particularly where the industry rested on a scientific basis. Many new industries have sprung up that are very limited in scope either because they are based on patents or chemical processes, or because, like many of the continuous process industries, such for instance as cement manufacturing and similar undertakings, they are naturally so limited. Again as the industrial field grew, manufacturers found that they could buy many things, formerly made in their shops in small quantities, much cheaper than they could manufacture them. Thus, formerly, every shop made its own small tools and appliances such as taps and dies, bolts, etc. But other men were quick to see that by manufacturing such supplies in *quantity* they could sell them to other manufacturing plants, that used them in small quantities, much cheaper than the latter could make them. The larger quantity was secured, of course, by supplying many users. The result has been that the factory of to-day is no longer self-sufficient to its purposes, but depends on many sources, not only for its raw material, but often, also, for the greater part of its tools and appliances great and small. It may, in fact, find it advantageous to manufacture certain sizes of a given product and rely on other factories for other sizes, depending upon the quantity of trade it can command. This tendency toward specialization grows constantly, the underlying economic reason being, as before noted, the advantages accruing from division of labor and transfer of skill.

There is a somewhat curious reversal[1] of this general law that sometimes occurs and that should be noted. It may occur that an enterprise may not, in the beginning, find it advantageous

[1] See also Chapter XIII.

to operate, say, a foundry, but because of the limited amount of castings used, can secure them from specialists cheaper than it could make them. As the business grows, however, there may come a time when the quantity of castings is sufficient to warrant the operation of a foundry, thus saving the profit formerly paid to the specialist. Thus as enterprises grow larger and larger their ability to manufacture all the accessories of their business increases and they are able to command a wider range of finished product. This is well illustrated in the great electrical manufacturing companies that now manufacture many of their own accessories such as porcelain, oil cloth, mica-board, etc., that formerly were furnished by specialists. There is often a great advantage in being able to manufacture these accessories aside from the financial saving, in that it affords a better control of the sources of supply, which is not a small matter in these days, when time of delivery is often an important factor.

23. Specialization of Men. As the field of an enterprise narrows, the character of its plant necessarily also narrows, the limit being reached in the form of continuous industries (Article 40) where practically no flexibility exists in the character of the process, each tool or machine being specially designed for its particular function, and no other. The range of the tools and the work of a specialized shop is, hence, narrower than those of the old general establishment, that now survives only in the form of the repair shop. This, of itself, tends naturally to narrow the field of action of the man employed in the industry and, in addition, the same influences that are narrowing the field of activity of each enterprise are also at work, internally, narrowing the field of the worker. This is so because greater output can be obtained when men are specialized, the skill and speed in any operation increasing with the specialization. These two influences, specialized machinery and the resultant division of labor, have already produced some very remarkable results. Not so many years ago the shoemaker measured his customer's foot and made the shoe or boot completely. To-day by means of specialized machinery and labor the making of a shoe is divided up into a great many operations, so that the operator may spend his entire life in

sewing one kind of a seam or running a machine for nailing on heels. Shoemaking as a *trade* has disappeared and its place has been filled by a highly specialized industry.

Certain factories make, as a rule, only a limited class of shoes and the operations of making them have become most highly specialized, following the specialization of the machinery, and other factory influences tending to extreme division of labor. This tendency exists everywhere, the influence of the new methods being always to narrow the field of the worker, and to require more special skill either of hand or mind.

24. Advantages and Disadvantages of Specialization. The advantages that flow from specialization should be noted. Obviously the product can be produced more cheaply than under the older general methods, and this, in itself, should benefit humanity. It is indeed this basic fact that has given these new methods such a strong hold upon the manufacturing world. With all the disadvantages of the new methods they have added tremendously to the comfort of living and can be made more effective in this direction if properly controlled. Because of the principle of the extension of the field of labor (Article 10) countless thousands of men and women are now employed in industries that they formerly could not have entered, and at higher wages than they could ever have obtained at the callings otherwise open to them. Undoubtedly the advantages offset the disadvantages but the disadvantages should not be overlooked or forgotten. The greatest of these perhaps is the destruction of the old trades and the disappearance of the old, all-around mechanic. This, in itself, would not be so bad if the changed conditions allowed an opportunity for those coming after to enter industry easily and advantageously.[1] But the passing of the old methods took away, also, the old apprenticeship systems leaving little or no provision for preparing men for industry. This, however, while serious is not beyond remedy. The change was so sudden

[1] The situation is paralleled in other lines. Thus the advent of the tramp steamer with its specialized crew has eliminated the sailing vessel with its all-around seamen. But no one would deny the economic advantage of the new methods though many may deplore the passing of the picturesque old "wind-jammer."

that manufacturers and educators had not sufficient time, or did not realize the situation, until the mischief was done. To-day, however, many influences are at work tending to supply this deficiency in our industrial system and there is great reason to hope that this need will soon be met (see Article 19).

Extreme specialization may expose a factory or other enterprise to serious financial outlay, if not ruin, because of sudden changes in processes, or new inventions. This has been markedly so in the New England weaving industries and similar highly specialized enterprises where the rapid advance in machinery has put a heavy financial burden on existing factories, thus favoring new manufacturers seeking an entrance into the field. Continuous processes, especially those depending on some chemical reaction for their methods, are always in danger from new and more economical methods especially if these latter are patentable. A highly specialized plant may often be at a disadvantage, as compared with one less specialized, in periods of depression when certain lines of product may not be in demand while others may be in good demand.

The same danger may face a man who is highly specialized. A change of process or a new invention may almost instantly eliminate his calling, and it is becoming increasingly difficult for a man to change from one calling to another of equal renumeration because of the special skill required in each calling. The tendency is always to make the distance between the worker and the tools of production wider and wider, with an increasing need of concerted regulation of industry to compensate for these disadvantages.

Standardization.

25. Economic Basis. Specialization, as has been noted, is the confining of human activity to a limited field. In industrial work this means the limitation of an enterprise to a portion of the field and to the production of a limited line of products. But even when the line of products is limited, there are usually many *types* that are possible in that line and an infinite number of *sizes* of any one type. Thus suppose a manufacturer specializes in the manufacture of men's shoes. Here there is no limit to the

types that may be produced and no limit to the number of sizes of any type since no two feet are exactly alike. Again a manufacturer may specialize on the production of motors between the sizes, say, of one-half horse-power and twenty horse-power. Here again many types are possible and an infinite number of sizes for each type. But it has been shown that one of the essentials of cheap production is *quantity*, and for a given *total* output the greatest number of each element entering into the product is secured when the numbers of types and sizes are a minimum. By **standardization** is meant the reduction of any one line to fixed **types** and **sizes.** Thus in the case of the manufacturer of shoes he selects a few types that, in his opinion, will find favor in the market. But each foot is not measured and a shoe of the required type made to these measurements. A limited number of sizes of each type is manufactured, these sizes being selected, by previous experience, so that any average man can find a pair that will fit him. The same holds true for the case of electric motors discussed above, and in fact for the entire field of manufactured products. Of course small quantities and special machines must always be made for certain conditions; but wherever goods are produced in quantity the above conditions apply. This form of standardization may be called the **method of the average solution.** It is applicable to all manner of goods from watches to locomotives. The basis for its use is, evidently, **economic production.** It is, in a way, an extension of specialization.

26. Interchangeability. There is another and very important ground for standardization and that is the desirability of having parts **interchangeable.** Standards of exchange have long been in general use, and these have, most usually, been fixed with a view to convenient use rather than on a scientific basis. The units of weight and measure are examples of this form of standard. They may not even be the most logical, or most convenient, but once established they can, in general, be changed only by slow degrees, if at all.

The importance of such standards will depend on the extent of their use. If widely used they may be definitely fixed in

character and magnitude for the protection of the public by legal statute, as is the case with weights and measures, thus securing accurate interchangeability of commodities. Again standards may be adopted in some line of industry for the purpose of securing interchangeability of product, and their importance may, through growth, be of such universal interest that they may become legally fixed. Thus it is entirely conceivable that our government in the interests of shippers and others might standardize, say, the gauge of railway tracks, or it might legalize industrial standards, such as screw threads, so as to secure universal interchangeability. It is presumed, usually, that such standards have been determined with such care and intelligence that they are the best that can be devised for the purpose. This is not always true, however, and, even if true, a standard that is satisfactory to-day may be far from being so tomorrow. The present system of gear teeth used in this country was very satisfactory until the problem of the automobile drive made other standards desirable. It is evident that standardization may be of state, national or even international importance.

Aside from the consideration of standards, as viewed from the standpoint of general use, either by the public or by a special industry, each shop may have its own special problem in standardization. A basic principle in mass production is that every machine element, or other manufactured part, shall be, as nearly as possible, exactly like every other similar element or part. This is necessary for three reasons. Every manufactured product is, in general, the work, not of one man, but of many men and is built up on the assembly floor (or corresponding place) from parts made by workmen who may never see the finished product. They may not even know, when doing their share of the work on the particular element on which they are employed, what the finished product may be like; nor, in general, is this information necessary to their work. A modern factory on mass production is like a river, the various elements *flowing* like tributaries from the different departments and merging smoothly into the stream of finished product that goes out

through the shipping room. Clearly the success of such methods depends on every element being exactly right or **standard** as they are termed.

Furthermore, accuracy of form in every element is important wherever duplicate parts are required. With machinery built by the old-hand methods a broken part could be replaced only by sending it to the factory as a model, or sending its exact measurements in some other way. To-day all manner of product, from watches to locomotives, are manufactured on the **interchangeable system** and repair parts may be ordered by **number** from the factory with a good assurance that they will fit into place with little or no work upon them. And even when the question of duplication is not so important, the very fact that each element must pass through several machines, or tools, requires accuracy and duplication of form. Thus spare parts are not needed in such product as shoes, and the accuracy of form required need not be so important as in making fire-arms; yet even in work of this character the fact that each element must pass through more than one machine or process, and the avoidance of accumulated error in the final product demand duplication and accuracy of form unknown in the old-hand processes. The extent to which this form of standardization may be carried will depend, of course, on the quantity to be made. Accurate duplication of parts is dependent on the character and extent of the *tools* employed and these, as has been seen, depend on the quantity to be made. The degree of perfection that has been reached in mass production in America is remarkable, and the method as before noted is being applied to all manner of manufactured goods. The modern machine processes of production lend themselves most naturally to this kind of work.

Nor does the idea of standardization stop with the consideration of each unit of product by itself. The same standard part may be used for several machines. Thus the same bedplate and frame may do for motors of several capacities; a careful study of several sizes of machines and machines of different kinds may make it possible to use the same part or parts in all of them, thus still further reducing the number of kinds of parts

and increasing the quantity of each. The general idea, therefore, is to reduce each line to the smallest number of types and sizes, not only so far as the finished units are concerned, but as far as the idea can be carried down into the details of manufacturing.

The idea of standardization may be extended to other and less material aspects of production. Thus if it is possible to find out which of several methods, or sequence of methods, will produce best results in doing a given piece of work the best combination may be recorded and used as a **standard method** of procedure, it being understood that this particular combination is the best, until some other better way is devised. Again where the element of time is concerned, as in fixing piece rates, a record of performance will enable the manager to establish **standard times of performance** that are valuable not only for setting piece rates, but also for predicting costs. Just as material standards tend to keep up the accuracy of the product, so standard times and methods tend to raise the quantity of product.

27. Advantages and Disadvantages of Standardization. The primary advantage of standardization is, of course, reduced cost. Not only is this true of the direct cost of production due to increased quantity, but also because as standardization reduces the required number of elements a corresponding decrease in the tools required naturally follows. The indirect expenses also decrease with standardization. Evidently less engineering talent and less clerical help and superintendence are required to handle a given output consisting of a few types and sizes than to handle the same output if consisting of many types and sizes. Standardizing the product reduces the variety of stores that need to be carried on hand, thus reducing the investment for a given output. It is evident that much more prompt delivery of product can be made with standardized goods than with those that must be built specially. To the customer, therefore, standardization insures prompt delivery, lower prices, and interchangeable parts.

Of even greater importance, perhaps, is the effect that standardization has on the **quality** of the product. Every machine or piece of finished product is, in the first instance, more or

less of an experiment, becoming increasingly so as its scientific and mechanical features become more complex. It is clear that the more a given machine is worked upon and the oftener it is built, the more perfect it will be. Standardized product is likely to be more satisfactory than special product for this reason, everything else being equal, and the customer should have very good reason for departing from standard types before doing so.

Standardization tends to concentrate the engineering and manufacturing talent of the factory with a consequent high development of product.

Standardization has, however, some serious disadvantages, and one of the most important is its tendency toward inflexibility, and hence toward impeding progress. Even in the case of standards of universal use this tendency is felt. Thus the metric system of weights and measures possesses many advantages over our present system; but there are so many serious objections to changing our standards that the introduction of the metric units has met with strenuous opposition. In England an antiquated system of money persists because of these same reasons. The standards of to-day though representing the best skill and knowledge obtainable may be inadequate or unsuited to the work of to-morrow. Our most widely used standards, such as standard weights and measures, standard bolts, flanges, gear teeth, not to mention our scientific standards, are objects of constant enquiry and criticism. Once a standard becomes widely used it is very difficult to change[1] it, and no one matter is of greater importance in organizing a manufacturing industry than the consideration of its general standards.

And these same criticisms apply to standardized product of all kinds. Once the types and sizes of a line of product are fixed for mass production everything pertaining to the production is standardized as far as possible. Drawings, patterns, special machinery and operations are all specially arranged for the work,

[1] No better example of this can be found than in a people's language. The difficulties experienced in trying to hasten changes in our own spelling that are obviously needed, is some indication of the difficulty the Chinese, for instance, would have in modernizing their written language.

and these cannot, usually, be changed or adapted to other types except at great financial loss. Special tools and processes are, as a rule, absolutely useless except for the purposes for which they are designed, and changes in type and size almost always mean heavy expenditures for new special appliances.

It has been said that America stands in danger of losing her manufacturing supremacy because of the extreme to which mass production has been pushed in this country. The tendency to resist change or improvement, and to use new ideas and new patents only when compelled to is, no doubt, strong where mass production prevails; and as enterprises become larger, and combinations of interest more common, this tendency may become very detrimental to progress. Serious as these drawbacks may be, they in no manner outweigh the advantages that accrue from mass production, and the tendency is to extend the method in all lines as fast as quantity will permit.

Division of Labor.

28. General Principles. It is human experience that as a man concentrates his efforts, either mental or manual, his skill in his chosen specialty, and the quantity of his product increase. It was shown in Article 23 that specialization in machinery had a powerful influence in specializing the workman and thereby extending the principle of division of labor. But division of labor may be furthered by other influences. The very growth of all lines of human knowledge and activity makes it increasingly difficult for one man to retain a grasp of any one entire field. He must be content to cultivate a small portion of it. Men of leisure may still cultivate scholarly habits and acquire broad learning, but in the industrial field and in other fields such as law, medicine, or teaching, or in fact wherever renumerative service is a factor, the tendency is to require more expert knowledge or skill rather than the older forms of general information. Even then the total knowledge of the expert may exceed that of the older all-round practitioner so vast has every field of knowledge become, while his expert knowledge or skill is vastly superior to his predecessors in the particular branch in which he has been

trained. This general tendency is true of all professions as well as of all humble callings.

29. Division of Mental Labor. The term division of labor has, from long usage, become associated in the public mind with manual processes. But productive labor is, in general, both *manual* and *mental* and just as there may be division of manual labor so there may be **division of mental labor** or **division of thought.**[1] Modern productive methods tend constantly to separate mental labor from manual labor and then to subdivide each into smaller and smaller parts. The subdivision of manual labor is greatly furthered, as has been seen, by the extended use of tools. Subdivision of mental labor on the other hand is hastened by an increase in the amount of knowledge and mental development necessary to successfully perform the work in hand. Thus the mental labor of designing machinery is performed largely apart from the actual production; and this mental labor has become very closely specialized as the scientific basis of engineering has grown. This process of subdivision is greatly hastened in both manual and mental operations by *increased quantity* since this, of itself, enables the manager to avail himself of the inherent advantages of division of labor already discussed.

The net result of these influences is to subdivide constantly all lines of human endeavor. Thus productive industries are usually divided, primarily, into three branches, namely, **financing, producing and selling,** the work of the first and last being purely mental. The productive branch is again divided into **planning** and **building,** as illustrated in the engineering and production departments of manufacturing establishment. This last subdivision should be carefully noted, as it is one of the best examples of a clear-cut division of the mental labor of production, so far as design is concerned, from the manual work of actual production. And it is to be carefully noted that the same influences that split factory organization into these fairly well-

[1] These basic principles which lie at the bottom of modern factory organization and administration were recognized long ago by Charles Babbage. See Economy of Manufactures, pp. 169 and 191.

defined groups are still at work *internally* in all of them. The work of the president of a large works may be entirely mental, while that of some of his assistants may be entirely of a manual character. The chief engineer of a large works does almost no manual labor, while the man who traces drawings does little mental work, and in between these two extremes will be found all gradations of combined mental and manual work. The scope of the department of a works engineer extends all the way from planning a new factory to the actual making of shop tools and fixtures.

All productive processes mental and manual were originally performed *in the shop* itself and in the case of very small shops this is often still the case. As works have grown in magnitude the continued application of the above principles has taken out of the shop a large part of the planning or mental processes and placed it in separate auxiliary departments. The much discussed methods of so-called "scientific management" aim, among other things, to carry the process still farther in the actual work of production. They aim to do the **mental labor of production** in a separate **planning department** and to **predict the results** of productive processes in a manner analogous to that in which the engineering department conducts the scientific part of machine design.

30. Summary. The economic principles and natural tendencies of the industrial field that have been discussed in the preceding articles, namely, transfer of thought and skill, division of labor, aggregation, specialization and standardization have had, and are still exerting, important and far-reaching influences, not only on industrial methods, as already described, but also upon industrial ownership, industrial organization, and more important still, upon our social and political fabric.

The problems of ownership and organization will be discussed in succeeding chapters and it remains to consider here, very briefly, the effect of these tendencies upon the workman.

As before noted the first effect of these influences is always to subdivide labor and to specialize men. This has already resulted in the disintegration of most of the old trades and the

substitution in their place of specialized men of many grades, varying from the manager or designer whose work is purely mental, down to the operative of whom little skill and almost no mental effort are required. Each worker, however, is more highly skilled and more productive in the particular operation that he performs than was his many-sided predecessor, the "all-around" mechanic. This specialization, of itself, is not so deplorable as might appear at first sight. It is not considered deplorable that a doctor specializes on one organ of the human body or even on one disease of that organ; nor that teachers now specialize in a few subjects, rather than trying to cover the whole realm of human knowledge. It is only in the cases where the operations are repeated rapidly, and require little skill or mental effort, but great concentration of attention that specialization becomes a menace to the worker. More enlightened management will see to it that operators on such work obtain the relaxation necessary to such work or communal regulation of some sort will insist upon it, as it has upon other similar reforms.

There is one effect of specialization, however, that should be carefully noted. Specialization tends to *classify* men; and as the numbers of any class increase the individual loses his personality in that of the class. He becomes, to the manager, simply one man out of many, all rated alike, and unknown to him perhaps, by looks or even name, a numbered cog in the great machinery of the works. The gap between the worker and the ownership of the tools of production is still farther widened by specialization and he becomes more and more dependent for his daily bread on conditions over which he has little or no control. Recognition of such superior qualities as he may possess either as a man or as a mechanic becomes increasingly difficult, the tendency of these influences being to standardize men in classes and fix their wages accordingly.

What more natural than that, under these circumstances, the best of men should turn to organization as a means of keeping the average wage of their class as high as possible? As the individuality of the worker is merged into that of a class, the

class naturally reflects only the common attitude and ideals of the individuals composing it, bearing on the object sought. Organization brings a sense of power, and the demand of the class is not what the several individuals of the class may be worth but a demand for as much as it can wrest from the employer. Everyone that has had experience knows that when men are classified and standardized the amount of work done by the better man falls off as his individuality is lost in that of the class, the standard of output tending toward that of the lowest producer. On the other hand, as has been shown, the demand of the class always tends to approach or exceed the compensation due the best worker. This condition is fair neither to employer nor employee and is the most difficult, and at the same time the most important problem of modern industry. It will be referred to again in discussing the problem of compensation of labor (see Chapter XI).

CHAPTER VI.

FORMS OF INDUSTRIAL OWNERSHIP.

31. General. The foregoing chapters will have made it clear that industrial organizations tend to become larger, partly because of the inherent advantages of the large plant that comes from production in quantity, and also because as the industrial field broadens, undertakings become larger in size and require larger plant and capital to operate them successfully (see Article 21). Growth, as already noted, almost necessarily involves a change in the manner of organization of nearly all kinds of industrial undertakings, and may also, though not necessarily, require changes in the manner in which the undertaking is owned. It is important to have clearly in mind the several ways in which a plant may be owned. These are

(1) Individual ownership.

(2) Partnership.

(3) Joint Stock Association.

(4) Corporation.

Any undertaking large or small may be owned in any one of these four ways. Large undertakings are usually owned by corporations for reasons that will follow, but there are many instances of very large undertakings that are held individually.

32. Individual Ownership. This form of ownership is, of course, the oldest and simplest and, in some respects, the most natural. Its characteristics are the same no matter how small or how large the undertaking may be. The individual proprietor is the supreme judge of all matters pertaining to his business, subject only to the general laws of the land and such special legislation as may affect his particular business. He may hire whom he pleases, and delegate such powers as he pleases to his employees. He may also conduct any and all lines of industry that he wishes to. The entire responsibility and author-

ity belong to him personally and the profits or losses are his own. His legal liability, on the other hand, covers all his possessions. The individual owner is not required to be legally registered, thus giving public notice of his business intentions, unless he wishes to operate under an assumed name, in which case he must usually register with some public official, and make a full statement regarding the business which he intends to establish, and state the name of the person responsible for all obligations and liabilities of the enterprise.

33. Partnership. As enterprises grow large the method of individual ownership may become inadequate. The duties and responsibilities may become too arduous for a single individual or the proprietor may desire to encourage valuable employees by a share in the profits. He may wish to associate with him men having capital or special skill and knowledge, so that for reasons of finance, personal liking or commercial gain, a partnership is formed. In these days of large undertakings a partnership is often formed at the beginning of the enterprise for reasons that are obvious.

A partnership, or firm as it is often called, is, then, a group of men who have joined capital or services for the prosecuting of some enterprise. The exact relations and agreements that may exist between or among them may vary. Thus one man may contribute capital, another experience or services, and another may contribute prestige, in any way that may be agreeable and satisfactory.

The law, in general, allows a partnership as much freedom as an individual in transacting business, and a partnership like an individual owner may engage in almost any number of legitimate enterprises without legal restriction.

It is evident, however, that since more than one proprietor is interested in the business it is important that the rights, responsibilities, and obligations of a partnership shall be legally defined; hence there is in all states a considerable amount of legal enactment regulating partnership. The necessity of this regulation is clearer when it is considered that every member of a partnership retains certain personal rights and obligations that

are not merged into his rights and obligations as a partner. Thus, in general, the law holds the firm, and each and every member thereof, legally and morally liable for any and all acts of every other member, committed in the name of the firm and within the scope of his authority as a member of the same. Each partner is responsible, financially, for all debts and obligations of the partnership, and judgment may be obtained and collection executed against the private property of the individual partners if the assets of the firm are not sufficient to cover the obligations of the firm. On the other hand, a partner is not responsible for the personal obligations of his co-partner incurred outside of the scope of his authority as a member of the firm. If a partner has financial difficulties, for instance, in building himself a residence, or if he should commit a felony in some way not connected with the business of his partnership, the firm is not liable, since these acts were not within the scope of his authority as a member of the firm. In fact a man might be a partner in several enterprises and would be responsible in such a case for the obligations of each firm only as far as his acts were within his authority as a member of each.

While the law, in general, allows a partnership almost as much freedom as an individual there is one form of partnership that is a little more closely restricted, namely, that which is known as a **limited partnership.** In this form of organization a partner may enter a firm under the condition that his liability or obligation is limited to the amount of his contributed capital. In such a case the firm must file a certificate with the proper official stating who the partners are, the extent of their liability, the place of business, etc., and give such publicity to its organization as may be necessary to protect those doing business with them. Usually the capital of each limited partner must be paid in and there must be one unlimited partner whose liability is not limited. This form of partnership is not very common.

34. Joint Stock Association. A joint stock association is a partnership with certain peculiar features that bear some resemblance to those of a so-called corporation which will be described later. Its organization must be authorized by law,

and it may assume a corporate name. It may issue stock to its members and this stock is transferable. It is formed, however, by mutual agreement of the members, and no publication of its articles of organization is required. A joint stock association may sue a member and may be sued by its members. The members, however, are individually liable for all debts and obligations of the association after the property of the association is exhausted. This form of organization is of little utility and is not often used. The name, however, should not be confused with that of *stock corporations* which are much different in character.

Corporations.

35. Nature and Classification. A corporation is, by nature, an artificial person created or authorized by legal statute for some specific purpose. It can have only such rights and privileges as are conferred upon it by law. These rights, privileges and obligations vary in different states, depending on the nature of the business and the force of public opinion. A corporation is composed, usually, of a number of persons; but it should be especially noted that these members or stockholders are not the corporation, which has an entity of its own and an existence entirely apart from that of its individual members. Consequently a corporation can carry on business in its own name only. A stockholder in a corporation is, usually, not liable for his indebtedness beyond the amount of his stock, differing radically in this respect from a partnership. In former times this was not so, and there are still special cases where the stockholder is liable for more than his holdings but, as a general rule, his liabilities are limited to the value of his stock. A stockholder may do business with the corporation, entering into a contract with it. He may sue it and he may be sued by it. In a corporation any man may sell his stock at will and any man, who may, can buy an interest in the form of stock holdings. In this respect, again, the corporation differs radically from the partnership in which no member can transfer his share of interest to anyone without the consent of the other members of the firm.

A corporation, as before noted, must be created by law. Individual owners may, as before stated, engage in any legitimate business without public notice, but in order to organize a corporation, a certificate of incorporation must be filed with the proper authorities. This certificate must, in general, contain

(1) The name of the proposed corporation.

(2) The purposes for which it is to be formed.

(3) The amount of capital stock and its division into common and preferred stock if there is such.

(4) The number of shares of capital stock and the value per share. Maximum and minimum limiting values are sometimes placed by law on the value of shares.

(5) The location of the principal business office of the corporation.

(6) The number of its directors with the names and addresses of the original directors.

(7) The names and addresses of the subscribers to the certificate and the number of shares that each agrees to take. The state will then issue a charter to the organizers, authorizing them to engage in the proposed business. A corporation is not, in general, permitted to engage in a business not fairly within the provisions of its charter, though the charter may be, and in the case of large corporations usually is, very broad and liberal.

Corporations are used for such a wide range of purposes that classification based on the purposes for which they are formed is useless and confusing. Thus corporations may be formed to manage a college or a church, an industrial enterprise, a railway system, a bank, or in fact almost any human activity. The only line of demarcation that is logical or useful divides corporations into

(1) **Public corporations.**

(2) **Private corporations.**

Public corporations are those formed by a community for governmental control and are often called **municipal corporations.** In general, all other corporations are classed as private corporations. Corporations formed to operate utilities that serve the public, such as railroads, gas and electric lighting

plants, telephones, and telegraph systems, are sometimes called **quasi-public corporations,** but if they are conducted for private gain they are properly classed as private ventures. The services which this class of corporations render make them much more interesting and important to the public, and they are increasingly liable to close regulation by legislation; nevertheless, if conducted for private gain, they are not public corporations. The control by the public of quasi-public corporations is especially important in a service that is a natural monopoly.

36. Capital and Capital Stock. The capitalization or capital stock of a corporation is the nominal capital authorized by its charter; that is, the number of authorized shares multiplied by their **par** or **face value** as fixed by the charter. These shares of stock are freely transferable and may be bought and sold at the market price like any other commodity. When a person acquires an interest in a corporation he is said to become a **stockholder** and his interest is expressed in shares of stock. The visible evidence of ownership is the **stock certificate** which certifies that the person whose name appears on the certificate owns a specific number of shares. Since these certificates are freely transferable, it follows that the ownership of a corporation may be, and often is, a constantly shifting body. Any purchaser of stock can have the certificates that he acquires exchanged for new certificates made out in his name, by presenting the old certificates properly endorsed by the former owner. The corporation recognizes as voters only those whose names are listed on its stock books at the time of voting, and the voting power of a member is measured by the number of his shares. The interest that any stockholder possesses in a corporation by virtue of his possession of stock certificates is an **undivided** interest; that is, he cannot withdraw the value represented by his certificate from the corporation which, as before stated, is an entity that cannot be divided unless the affairs of the concern are closed up and the residual assets after liquidating all liabilities divided, in which case each stockholder would receive his pro-rata share.

The entire amount of stock authorized by the charter of a

corporation need not necessarily be issued. When stock certificates are issued, and paid for in full, they are designated as **full paid.** If any authorized stock remains unissued it is called **unissued stock.** Evidently such unissued stock has potential value only and cannot be considered an asset. If stock is issued and paid for in full and then by gift or purchase comes again into the possession of the corporation it is called **treasury stock** and is usually treated as an asset.

Stock may be of two kinds, namely, **common** or **preferred.** Common stock is the general or ordinary stock of a corporation which has neither special privilege or restriction of any kind. Preferred stock is stock having some special preference over other kinds in the matters of dividends or assets of the corporation. Thus a corporation may issue both common and preferred stock, binding itself to pay a definite dividend on the preferred stock before any common stock can receive a dividend. In some states it is provided by law that preferred stock may not receive over a given per cent of the par value in dividends. After the dividends on preferred stock are paid the remainder of the profits are usually divided equally among the common stock, though sometimes the preferred stock also participates with the common stock in such further distribution of profits.

The difference between preferred stock and a **bond** should be carefully noted. Dividends on preferred stock, or common stock, can be paid only if there is a *profit.* Interest on a bond must be paid whether there is a profit or not. It is an obligation usually incurred by borrowing money, giving a bond, which is secured by a mortgage on the real property, as a guarantee. The interests of bondholders and stockholders may, therefore, be radically opposed.[1] A bondholder will be desirous of keeping the real capital of the company intact since that is his security. A stockholder is interested in dividends and does not usually care whether they come out of profit or are a part of the capital itself, as is sometimes the case where works are badly managed.

[1] These differences of interest are often important in such matters as appraisement and depreciation. See Article 87.

A clear distinction should be made, also, between the *capital stock* of a corporation and the assets or actual property that the stock is presumed to represent. The capital stock, as before noted, is the total amount of the stock authorized by the charter. It is fixed by the charter and may not be changed except by authority of the state. The true value of the property that the corporation possesses may or may not be the same as the capital stock.

In conservative enterprises the capital stock usually corresponds, in the beginning, to the actual value of the assets, that is, for every dollar of stock issued by the corporation it receives a dollar in cash or property. When, however, the enterprise becomes active, the actual value of the assets may be greater or less than the capitalization, depending on the success of the business. In enterprises of a speculative character the capital stock is often intentionally fixed greatly in excess of the value of the real assets, either to sell the stock profitably at a price below its apparent value, or in the hope that the future earnings will justify the capitalization. Such enterprises are said to be **over-capitalized** and the stock is said to be **watered.** The same result occurs when a corporation takes over a property, issuing stock certificates in payment thereof, the face value of which is greatly in excess of the real value of the property taken over. Even in such cases, however, there may be intangible assets such as good will, trade-marks, etc., that may justify the over-capitalization so far as earning power is concerned. In fact in some enterprizes, such as magazines and other publications, the greatest asset that they possess is good will, or " capitalized earning power " as it has been called, and in the case of a successful publication this may be a very valuable asset, though, strictly speaking, an intangible one. There is, nevertheless, a growing tendency to prohibit the watering of stock.

The **net worth** of a business is the difference between its assets and its liabilities. In a corporation the net worth is equal to the par value of the capital stock, plus the surplus or minus the deficit due to trading, at the time under consideration. If there are no liabilities the net worth is the value of all the assets

possessed by the corporation. The market value of a share of stock will depend, therefore, on the relation that exists between the net worth, the amount of stock issued, and the earning power of the corporation. If the net worth is greatly in excess of the issued stock, and if the dividends be high the value of each share of stock is enhanced and it may sell at a price considerably **above par.** If the dividends should fall, without change in the net worth, the market price of the stock would decrease so that even in such a case it might sell **below par.** If the net worth decreases, the stock may fall in value even though the earning capacity remains good; while it is evident that any variation in the earning power will cause a similar variation in the market value of the stock. The effects of these influences are modified, also, by the general reputation and standing of the enterprise and the consequent confidence that the public may have in the success of the venture. It should be noted that the term net worth as here used is not synonomous with *actual net value,* since the assets, as before noted, may contain intangible assets which, nevertheless, are often very valuable.

The assets of a concern that are permanent in nature, such as buildings, real estate, machinery, etc., are known as **fixed assets.** Assets that are constantly changing in character and relative amounts, such as cash, accounts and notes receivable, merchandise, etc., are called **quick** or **current assets** or **floating capital.**

37. Corporate Organization. Directorate. The actual administration and management of a corporation is vested in a board of directors elected by the stockholders, most usually for a term of one year. (Bondholders, it will be noted, have no vote.) The directors elect the officers of the company and appoint all important officials. In some states the law requires that certain specified officers, such as president, secretary and treasurer, shall be elected or appointed. In large organizations there are usually a number of vice-presidents, each at the head of an important branch of the work, the exact organization varying with the work. (See Article 41.) The powers that may be vested in any one officer will, of course, vary with circumstances.

Very often an executive committee composed of a small number of directors that can be called together quickly and easily for consultation with the president, or general manager, is given large discretionary powers, but, in general, very important issues are settled by the full board of directors. The question of directorship is, hence, an important one and often leads to strenuous efforts to obtain control of stock so as to influence the election of these important administrative officers.

38. Advantages and Disadvantages. The corporate form of organization has several advantages over the simple partnership. Evidently a large number of people can participate in an enterprise by this method and a large amount of capital can be assembled by this method, though no one stockholder may be a large investor. The method, therefore, lends itself readily to enterprises involving large capital outlay. There is an element of *permanency* about a corporation that cannot be attained by a partnership since the continuity of a corporation is not seriously affected by a change in either the management or the owners. The death of a partner may seriously affect a partnership and the death of a single proprietor may close up the business; but the death, or withdrawal, of any number of stockholders or directors does not necessarily affect the corporation which, as before noted, has an entity of its own. Disputes over the ownership of stock, even in adjusting the estates of the deceased, can have no effect on the corporation. In fact, enterprises that are really individually owned are sometimes incorporated, the owner giving or selling a few shares to friends or relatives so that the business may be organized in such a manner as will insure its continuance after his death. For these reasons there is an increasing tendency to incorporate industrial enterprises. The Bulletin[1] of Manufacturers of the Thirteenth Census of the United States reports that in 1904, 23.6 per cent of the total number of manufacturing establishments of the country were incorporated and in 1909 the percentage had risen to 25.9. The corresponding percentages

[1] See Thirteenth Census of the United States — Bulletin of Manufacturers, p. 24.

of the value of the goods manufactured for the same years is given as 73.7 and 79 per cent of the totals.

On the other hand, the buying of stock in any incorporated enterprise requires care and insight for success. From the foregoing it is clear that assets and capital stock are two very different things and unless a buyer has a good knowledge of the real state of the affairs of the corporation in which he invests the investment is more or less of a hazard. Again, stockholders who do not agree with the methods of the managing directors have no means of changing those methods if they are a minority of the stockholders. If the majority of the stock is held by a few men they can dominate the policy of the business without regard to the opinions of the minority.

The many and varied issues that have arisen in connection with corporations have given rise to a large number of legal enactments known usually as **corporation law.** As enterprises have grown in size and power they have in very many cases not only evaded the limitations of the law but have been oppressive to other interests. There is an ever-increasing tendency to regulate all forms of corporate ownership much more strictly than in the past, especially where the enterprise is of a quasi-public nature. This legal regulation of corporate organization is one of the most important and also most difficult problems that faces us to-day. As has been shown in Article 21 the natural tendency of all successful enterprises is to increase in size because of economic considerations. To permit corporations to grow to large sizes and at the same time to insure the return to the common people of the benefits so derived seems to be no easy task.

39. Coöperative and Governmental Ownership. No discussion of industrial ownership would be complete without brief notice, at least, of coöperative ownership, though anything approaching an adequate discussion of this phase of the subject is far beyond the scope of this book. Coöperative ownership as a means of obviating the evils of the present industrial system has been advanced by many able men[1] ever since the inception

[1] See Life of Robert Owen, by Lloyd Jones.

of the factory system. Theoretically, it would seem possible that men could combine their interests and share their profits fairly and amicably; but in the practical working out of such schemes there are many difficulties. Such schemes are not new[1] and under simple conditions of living and more uniform requirements of those concerned than can, as a usual thing, be found in the present industrial world, such schemes may be successfully operated. In fact, in the present era, those co-operative schemes of large size that may lay claim to any great degree of success have been operated mostly by people held together by some kind of artificial bond, as for instance some form of common religion that has had a unifying and levelling effect.

If the requirements of the industrial field were uniform and if all men were equally able, mentally and bodily, the case would be different. The needs of the industrial field are many and varied, requiring men of all grades and capacities; and the diverse requirements of the field are equalled only by the differences in the capacities and abilities of men. Even though common ownership in comparatively small undertakings be granted as a possibility, the equal division of profits, so much talked about, is possible only through universal mediocrity or a spirit of self-sacrifice on the part of the more able members of society far greater than has ever been displayed in this era. In this last respect we are somewhat behind some civilizations that have preceded us. Society has, in general, always had to pay for services rendered in proportion to their value and it is difficult to conceive of the efficient operation of the present industrial methods on the ground of common ownership without such differences in compensation as will most naturally tend to perpetuate the social differences that we now complain of.

True, many governments are now operating very successfully several lines of national utilities, such as railways and post-office systems; but even here these differences in compensation exist. There is a vast difference, however, between governmental ownership of a limited number of state-wide or

[1] See Industrial History of England, H. deB. Gibbins.

national utilities and governmental ownership of all tools of production.

Nevertheless these socializing doctrines have had, and will continue to have, a profound influence on our ideas of ownership. They have already resulted in governmental regulation that would have been considered impossible[1] a few years ago and, if then possible, they would have been considered an infringement of personal liberty. No one, whether interested in industry as an owner or as an employee, can afford not to study these tendencies carefully. They come as a direct protest against the social differences resulting from the absolute separation of the worker from the tools of production and are an effort to restore that lost ownership. **Governmental regulation** is even now with us; how far we may go in **governmental ownership** is a problem not of the next century, but of tomorrow.

Reference :

The Modern Corporation, by Thomas Conyngton.

[1] Note, for instance, the legal regulation of the price of upper Pullman berths.

CHAPTER VII.

PRINCIPLES OF ORGANIZATION — SYSTEM.

40. General Principles. The great advances in the mechanical features of manufacturing have, necessarily, had their counterpart on the administrative side. As enterprises have grown in size the simple *personal* methods of conducting the business of the factory and controlling men have become inadequate and have been replaced by methods less personal. The management of a large industrial enterprise is no longer the work of a *boss*, for though personality is still a great factor in management; to be successful it must be reinforced by a knowledge of many things unknown to, and not needed by, the old-time superintendent.

All branches of human activity have risen above the stage of empiricism and rule of thumb only as they have been able to build upon the accumulated facts of experience and accurate conclusions drawn therefrom. Industrial organization and management is no exception to this rule. Until quite recently industrial management has been largely personal and empirical, rule of thumb methods being almost universally used in all matters. The need of more accurate information, especially in administering large enterprises, has led, however, to a more careful examination of the art of management with a view of finding whether any basic principles existed that might serve as a safer guide than the cruder empirical methods; and with the hope that a better understanding and more accurate solution of these problems would come with a fuller understanding of these basic laws.

Such basic laws do exist; and the term **industrial engineer** is becoming synonomous with one skilled in factory organization, who endeavors to rest his conclusions, not on simple empirical information or judgment, but, as far as possible, upon

basic observed facts. The *scientific method* that first observes and records the data of the phenomena concerned, then deduces the fundamental laws of the phenomena from these data, and lastly applies these deductions to predict other results has come to stay in all lines of human activity. Just as the designing engineer endeavors to obtain highest efficiency by eliminating energy losses, so the industrial engineer is a close student of wastes in manufacturing processes. Just as the designing engineer seeks to rest his work on accurate data and scientific facts, so the industrial engineer seeks to observe, record and formulate the data of industrial operations and industrial management in order that he may accurately predict the results of other operations and arrangements. His field is indeed a wide one, ranging from the collection of statistical data of the industry as a whole, down to the shipping of the factory product, and his sources of knowledge have their roots in engineering, economics, psychology and other fields of human experience. These relations and conditions apply, in general, to all forms of industry, but apply with special force to industries involving congregated labor, as found in manufacturing plants, and a discussion of the special problems found in organized manufacturing will exemplify those of almost any other form of industry. These general principles apply also to all phases of manufacturing industry, including construction, equipment and operation.

More than ever, perhaps, the successful manager must be a close student of men and their psychological processes. With the steady rise in intelligence, the increasing complexity of personal relations and the growing tendency of the public to interest themselves in industrial matters, the human element in factory management looms up with increasing importance; and no system of management can be successful that does not take this factor into account. Just how far such human relations can be said to be open to scientific methods remains to be seen, though there is no lack, even now, of those who claim that these also can be measured and recorded.

The application of these well-known scientific methods to

industrial organization and management has become known as **efficiency engineering, industrial engineering** or **scientific management.** The last title has been, perhaps, not well chosen and has created some antagonism to the use of these principles, partly because of a lack of knowledge regarding the basic facts and partly because of a well-grounded fear that there is grave danger in extending, to the extreme, some of the methods advocated. Whatever name may be applied to this work it is certain that the scientific method of attacking the problems of organization is correct, and that it points out the method of intelligently directing the construction and arrangement of factory buildings, the character of methods and processes, the organizations of departments, the elimination of wastes and the increase of efficiency in all phases of industrial administration where data and experience are applicable.

Now it has been shown that the following important principles underlie the economic production of manufactured goods:

(*a*) Division of labor, including separation of mental and manual labor.

(*b*) Transfer of skill.

(*c*) Transfer of thought.

It has also been shown that these methods are more effective as the quantity to be made increases, specialization and standardization also being dependent on aggregation or quantity.

It may be stated, therefore, that

(*d*) The unit cost, in general, decreases as the quantity increases.

It is evident, also, that as enterprises increase in size, as division of labor is more fully applied and departments multiply, increasing care must be used to **coördinate** the work of men and departments; hence, it may also be stated that

(*e*) The need of coördinative influences increases with aggregation and division of labor.

And, lastly, it is obvious that any principle gains in effectiveness if applied systematically on the basis of recorded experience rather than empirically. The above-named principles will, therefore, gain in value if applied in connection with

(*f*) The systematic use of recorded experience.

Aside from the human factors involved these may be taken as the most important principles in manufacturing production. The succeeding chapters, with the exception of the last, are devoted to their application to the problems of organization, and the problems of some of the most important departments resulting therefrom as seen in present day practice. In the last chapter the limitations of these principles as a scientific basis of the art of management will be briefly discussed.

It is obvious that the departmental organization of a plant will depend largely upon its size and the degree to which it is specialized. Increased size naturally brings with it greater subdivision of labor and the consequent need of added coördinative influences. Under the older and simpler systems of production, when small numbers of men were the rule, the relations between master and man were very simple. Each man was competent to perform any and all operations, producing perhaps the entire article himself. The instructions, few and simple, were given verbally, and duplication in a modern sense was unnecessary. As the size of industries has grown, as specialization and division of labor have been extended and as special or scientific knowledge has become more and more necessary, these simple relations have been forcibly expanded and the concerted labors of master and man have been replaced by administrative, planning and constructive **departments**, to properly coördinate the work of which has become a study in itself.

The tendency toward complexity in organization due to increased size is not so great, however, as that due to the character of the industry and the degree to which it is specialized. Manufacturing industries are, broadly speaking, of two general classes, namely, **continuous** and **intermittent.** In a continuous process the material goes in at the receiving end of the plant, is worked continuously and appears at the shipping room as finished product. A continuous process may be either **analytical** or **synthetical**; that is, it may take some natural product and separate it into component parts or change its general form; as, for instance, the industries built on salt products, ore, oil and sugar

refineries, saw-mills, etc. Or they may take a few natural products and passing them through fixed processes build them up into some other form, as may be seen in paint works and wall-paper factories. In general, such industries deal only with a few raw materials, these passing in at one end of the factory and *flowing*, so to speak, through a number of fixed processes and passing out at the other end in the form of a limited number of finished products and by-products. The organization that the personnel of such a plant will most naturally take will depend on the character of the industry, but will, in general, be comparatively simple.

Intermittent or interrupted industries, on the other hand, may take many kinds of raw material, carry them to any desired stage of completion, store the finished or semi-finished parts when necessary and assemble the various kinds of finished product as the market requires. This finished product may cover a wide range both as to relative size and character. Ship-building plants, agricultural implement works and plants manufacturing electrical machinery are excellent examples of interrupted industries which form by far the larger part of organized industry. The above classification is, of course, not clearly defined; in fact, these types of industry represent extreme cases rather than distinct classes. The natural tendency toward specialization constantly tends to limit the range of intermittent processes and this, in an extreme case, might reduce a factory of the intermittent type to one of the continuous type. Many factories, indeed, have both continuous and interrupted processes in operation at the same time. Plants of this kind tend naturally to divide into departments and are naturally more complex in character than those of the continuous type.

Aside from these considerations, the exact form of organization of any plant nearly always depends, to some extent, on the character and ability of the men available. Able men are always rare and the exact subdivision of authority and responsibility often depends on this factor rather than on a more logical basis of an abstract analysis of the problem. For this reason and the other reasons advanced above, it is not possible to formulate

fixed rules for planning industrial organizations. There are, however, certain general principles that long experience has shown to apply to all forms of organization and that are, therefore, worthy of note.

41. Military or Line Organization. It is obvious that, where the efforts of large bodies of people are to be directed, **discipline** is an essential feature of the plan of organization whatever it may be. The oldest and most natural form of organization,

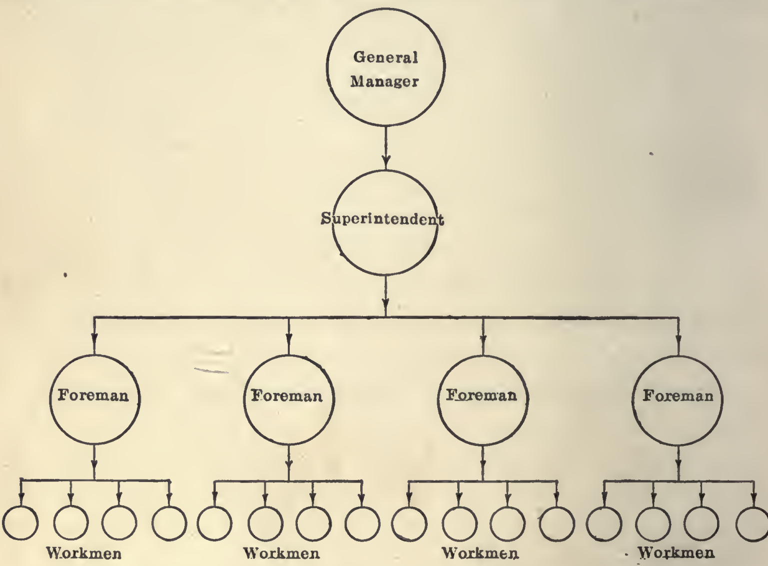


FIG. 2. — MILITARY OR LINE ORGANIZATION

therefore, is that which is usually called **military or line organization,** so-called because it was the essential feature of military systems. As used at present the name is a misnomer as military systems have been subjected to the same modifying influences that have affected industrial and other organizations.

Under this system the lines of *direction* and *instruction* are vertical, so to speak, and the growth of such an organization may be illustrated by Fig. 2. Here as the duties and responsibilities of the general manager grew beyond his physical and mental capacity he deputized certain of his duties to his superintendent. The latter, in turn, as he became overburdened,

engaged foremen to assist him and to administer the several departments, the workman being held responsible only to the foreman immediately above him. The lines of authority and instruction run directly down from manager to workman and all men on the same authoritative level are entirely independent of all others similarly situated. A foreman receives neither instruction nor command from another foreman and he can give the same only to those directly under him. The duties delegated by the manager to the superintendent and from the superintendent to the foreman, or in fact by anyone to another lower down are of the same general character. Thus the instruction given to each foreman would be of the same character but pertaining to different parts of the work or different lines of product. The proportion of both mental and manual labor is approximately the same for all men on the same level and such separation of mental and manual work as does exist comes from the natural reservation of mental work pertaining to administration by those higher in authority in delegating surplus duties to those under them. That is, division of mental and manual processes is, here, incidental rather than the result of logical study.

The advantage of this form of organization, so far as discipline is concerned, is manifest. The duties and responsibilities of each man are clearly defined and no misunderstanding need arise as to each man's sphere of activity. It has, however, grave limitations and, because of these, pure military organization is no longer found in undertakings of any size or complexity. As plants grow in magnitude this system tends invariably to load up a few men to the breaking point with a variety of duties, since the number of executives on any one level is limited. It tends also, therefore, to crude methods, since few men can do several things and do them well, particularly if these duties are decidedly different in character. Thus if the superintendent undertakes, as he formerly did, to be both administrator and chief designer he is not likely to be a great success in either capacity, as these duties call for characteristics not usually combined in one man. The instructions given to individual workmen re-

garding the prosecution of the work are necessarily meager, especially if the work is varied, hence reliance must be placed, to a large extent, in the knowledge and skill of the workman. And lastly, this form of organization tends to make the success of the undertaking depend, to a large extent, on the ability of a few strong men, the loss of any one of whom would be very severely felt. The military system has, therefore, seldom existed in a pure form even in military organizations, except where the number of men involved was small and the scope of the scientific basis of the undertaking narrow, as is sometimes the case in simple continuous processes.

42. Staff Organization. Suppose, however, that as the business grew there came, also, an increasing need for expert advice along the lines, for instance, of engineering and chemistry. And suppose the general manager instead of trying to supply this information with the aid of his superintendent, divided the mental and manual work and deputized it in the manner indicated in Fig. 3, a chemist being engaged to give expert advice in that field, an engineer doing the same for the engineering required and the superintendent retaining control of the actual production. Here (Fig. 3) the engineer, the chemist and the manufacturing superintendent are all on the same authoritative level, no one being above the other, and each being supreme in his own department except as he is responsible to the general manager. The engineer supplies the drawings and engineering knowledge, the chemist supplies the expert knowledge for certain shop processes and the superintendent of production controls the actual carrying of the work through the shop, and the hiring and disciplining of the men, etc., all three being advisory to the general manager. Now, each foreman receives instruction from three sources, each source being supreme in its own field of effort. Such a system is known as **staff** or **functional** organization.

It is very evident that the foremen in Fig. 3 will be much more intelligently directed than those in Fig. 2, particularly so as the scientific basis on which the industry rests becomes greater and more complex. Suppose, now, that the duties of each foreman

are not the same but that each is charged only with the supervision of certain aspects of each workman's duties and that the instruction that each foreman receives from the three primary sources is somewhat different from his fellow foreman's instructions. Each workman will then be guided by instructions from four separate men each one of whom will give him expert guidance in some phase of the work in hand.

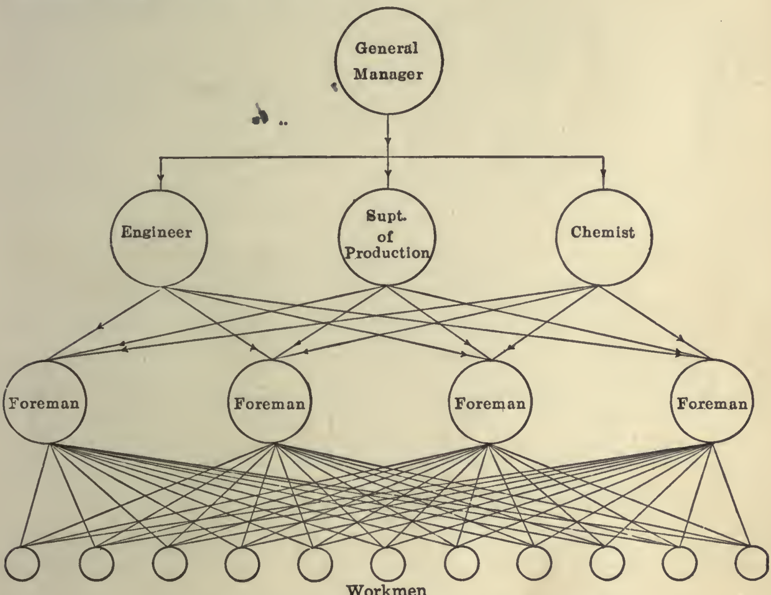


Fig. 3. — Functional or Staff Organization.

The advantages of this form of organization are manifest. It conveys expert knowledge and guidance to each workman through experts, and not through foremen partially educated in the several fields. The separation of mental and manual labor is planned *with reference to the functions to be performed* and not as incidental to other phases of administration. It makes provision also for the fullest use of the principle of division of labor by keeping the functions that each man is called upon to perform down to a minimum. It tends, therefore, to high functional efficiency in each and every man.

The greatest disadvantage of the system is that it tends to

become unstable because of the weakening of disciplinary or line control unless proper means of coördinating the work of men and departments of the same authoritative level is provided. The success of the system, when carried out in large enterprises, rests largely on the ability of the managing authorities to correlate the work of strong personalities and have them work together harmoniously.[1] Since the separation of mental and manual work is a fundamental principle in this type of organization its application to the lower grades of production has led to considerable criticism on the ground that an extreme extension of the principle makes automatons of the lower grades of workers. This feature will be discussed elsewhere.

43. Line and Staff Organization. It would seem, therefore, as though an organization to be most effective must include the good features of both of these important principles. Up to the present there has been no lack of appreciation of line organization, but staff organization as a cardinal principle has not, until recently, received the attention which it deserves though it has been used unconsciously, so to speak, by many managers for a long time past. The work and writings of Mr. F. W. Taylor,[2] in particular, have done much to call attention to, and awaken interest in, the use of this principle.

The organization shown in Fig. 4 represents fairly well the extent to which these two principles are used in the majority of progressive factories. Here the primary functional divisions are Sales, Engineering,[3] Manufacturing and Finance and the heads of these departments are on the same authoritative level, no one being above another. Each one, however, has a certain amount of line organization under him. The factory superintendent receives advice and instructions from the chief engineer and treasurer and is responsible to the factory manager for the general conduct of the factory.

[1] The late Walter C. Kerr once said, "The temperamental question is the greatest one in all management."

[2] See Shop Management, by F. W. Taylor, Trans. A.S.M.E., June,1903.

[3] Engineering, strictly speaking, is a subdivision of manufacturing so that the three fundamental divisions, sales, finance and manufacturing are represented in Fig. 4.

Under the superintendent, again, are functionalized the shipping clerk, tool designer, order department and inspection department. The tool designer and the inspector furnish expert knowledge and advice to each department foreman, and the

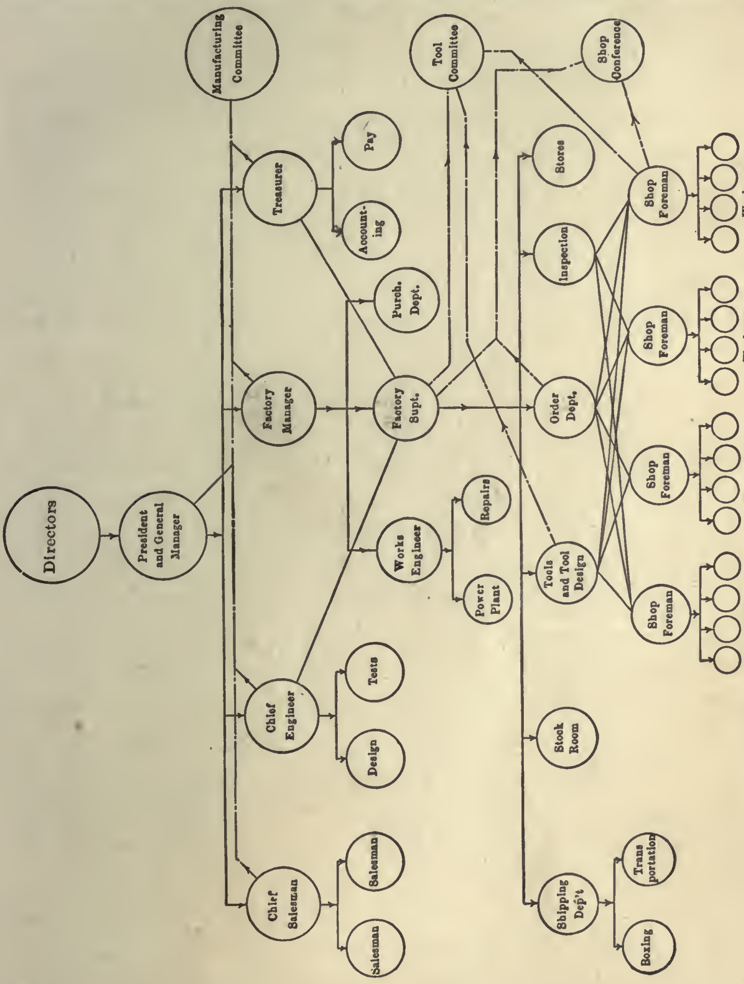


FIG. 4. — LINE AND STAFF ORGANIZATION.

order department directs all matters pertaining to actual production. Combinations of line and staff organization down to this point are not uncommon but the adoption of full staff organization (as in Fig. 3) or even of combined staff and line

organization below this point has been attempted in a comparatively few instances. The tendency, however, is in the direction of extending staff organization as far down as possible and this is one of the basic principles of so-called "scientific management."

It must be remembered that the amount of subdivision of labor that is justifiable depends on the size of the plant, the character of the industry, and the personality and ability of the men available for the organization. It is difficult to find men exactly suited to the requirements of a position and Fig. 4 must, therefore, be considered as an average or approximate arrangement. It is easier to adjust the scheme of organization than to change personalities. A fuller discussion of the limitations of these principles will be more effective after examining some of the problems involved in actual factory administration.

Coördination and Executive Control.

44. Coördination. It is obvious that any plan of organization to be highly effective must be definite; that is, it must define clearly every man's duties and coördinate every man's efforts toward the desired result. The duties of every man and every department should be outlined as clearly as possible and the authority and responsibility of every man definitely fixed. Authority and responsibility are inseparable and are essential to effective service. It is not good policy to keep men in uncertainty as to their position in the organization, and when several men are on the same authoritative level their several fields should be carefully prescribed and their efforts carefully coördinated. This is particularly true when a considerable amount of staff organization is introduced, since this tends, naturally, to weaken the disciplinary effects of line control; and where staff organization is used to any marked degree special care must be used to supply coördinative influences to compensate for this weakness.

While a certain amount of coördination can be accomplished by means of personal influence it is obvious that where large numbers of men are involved, or where preplanning of the work

is necessary, written documents must be resorted to. For instance, an **authoritative diagram,** such as Fig. 4, facilitates a clear understanding of the relations between the several officers and departments. In some cases the detail duties and authority of men and departments are issued in written form and copies of these instructions are bound up into an **organization record**[1] that serves as a permanent record of the organization. Whether such a volume is necessary or not the duties of men and departments should be issued in writing, and necessary adjustments between men made by some one higher up and not allowed to remain a constant source of irritation and dispute. The specifying of the duties of the several men has the added advantage of compelling the organizer to think out his plan of organization with the same care that a designer of a machine bestows upon the several parts to insure smooth running.

45. Administrative Charts. It is important that the orders and reports issuing from any department go to the proper persons and to them only. It is not necessary or desirable for the general manager to notify every shop foreman of important details of the business and it is even less desirable that reports showing important data bearing on shop costs, for instance, should go to any but the proper authorities. For this reason it is often an excellent plan to lay down an **administrative chart** such as is shown in Fig. 5. The diagram shown in Fig. 4 is very useful in showing authoritative relations, but an analysis, such as Fig. 5, showing the men and departments that are to have communication with each other is more useful in actual operation. In Fig. 5, which includes the same men and departments as Fig. 4, the men or sub-departments that are attached by the military system to each department are arranged concentrically around each department head for the sake of greater clearness. In some cases it adds to the clearness of the diagram by locating the several departments with reference to their geographical relation to each other and it then serves, also, as a basis for a messenger service when it is necessary to install one. The character of the information which is to pass between the several

[1] See Applied Scientific Management, by F. A. Parkhurst, pp. 11 and 199.

departments can be worked out and its passage indicated by directive lines drawn between them. Orders may be indicated by one kind of line and reports by another.

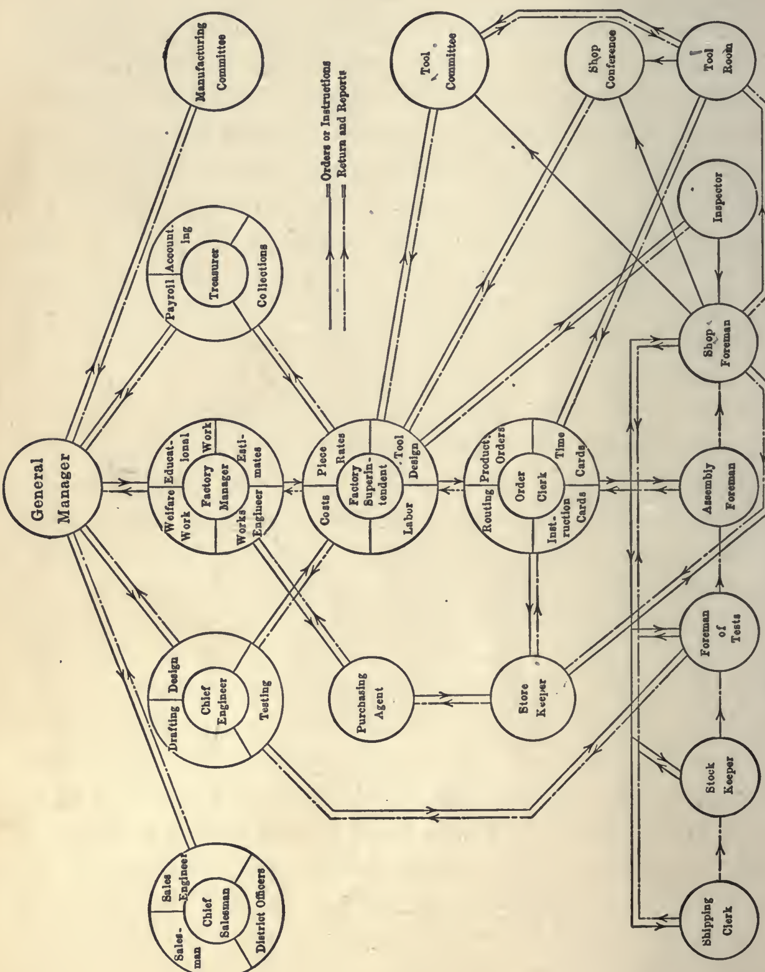


FIG. 5. — ADMINISTRATIVE DIAGRAM.

46. Orders and Returns. It is evident that as the plant grows in size and organization becomes more complex the manager loses *personal* touch with both processes and men. In smaller shops and under simpler methods the manager was able to

assure himself personally of all the details of the business, to know each man's abilities and hence to use them to the best advantage, retaining his interest in the work on personal grounds. He could settle all disputes and differences personally and the manager's personality played a large part in the administration of the works. This personal method of giving orders and checking up results is, evidently, no longer possible with modern organizations, even where small numbers of employees are concerned. As the numbers grow large the problem increases in complexity and must be solved by a carefully arranged system of *written* communications. It is a cardinal principle in modern management that all directions and instructions and all reports and returns must be in written form of some kind. This gives *definiteness* to all such matters and, through duplicate copies, records of all transactions can be preserved. It also enables the manager, or others interested, to trace faults and errors and place the responsibility where it rightly belongs.

There are, in general, only two classes of such documents, namely, **orders** and **returns.** Under orders may be classified all instructions and directions issuing from the several departments charged with directing the work, making purchases, etc.; and under returns may be included documents and reports recording the results of operations, accounts of materials, time, supplies and other data; or, more briefly, orders direct how work shall be done; returns record how it has been performed. For convenience and dispatch, orders and returns are usually made on printed forms so that the amount of information that must be filled in by hand is a minimum. These orders and returns move to and fro along the pre-arranged lines of communication of Fig. 5 and if the system is adequate each department is fully informed regarding what it should know; confidential information goes only to those for whom it is intended, and the results obtained are much more accurate than can be obtained by any personal direction.

The relative size and the character of the printed form on which orders may be written will, of course, depend on the character of the work and form of organization. It is of little use

to try to indicate, even briefly, their general character as they grow out of the needs of the business.[1]

Fig. 6 shows a typical production order issued by the production clerk directing a department to perform certain work. The written order enables the manager and the several heads of departments charged with the direction of the work to issue their directions with a clearness, accuracy and surety that cannot be approached by verbal methods. This is very well illustrated in the work of the engineering department. The

	Pattern or Part No.	To Dept.	Date of Order	Requisition	Specification No.	Drawing No.	Prod. Order No.
	Please execute the following order, returning this slip on completion of work to Stockkeeper. Order to be completed by Charge all labor and material to the above Production Order No. and Pattern or Part No. Parts prefixed by Dept. Letter are not in Stock and will be made by that Dept. on above Prod. Order No. and delivered to Dept. and by scheduled date as shown.						
	Description of Order						
	Deliver to Dept.						

		Quantity and Description of Material to be used. Date required in shop		Date	Dept.
Date order completed			Approved		

FIG. 6. — PRODUCTION ORDER.

drawings and specifications issuing therefrom can be, and should be, so made as to make verbal communication almost entirely unnecessary.

The returns from factory operations and transactions are of a necessity numerous and of many kinds. Detail records of all time expended, material used, supplies ordered, progress of work, etc., are usually obtained by a carefully arranged system of cards which are filled out at the place of operation and then

[1] See Factory Organization and Costs, by L. E. Nicholson; Commercial Organization of Factories, by J. S. Lewis; Factory Costs, by F. E. Webner, and similar books for typical forms of orders and reports.

returned to the department interested. Thus the engineering data and the records of tests made on the product would go to

WEEK ENDING ______

No.

Name ______

DAY	MORNING		AFTERNOON				TOTAL
	IN	OUT	IN	OUT	IN	OUT	
SUN.							
MON.							
TUE.							
WED.							
THU.							
FRI.							
SAT.							

TOTAL ______ HRS.			
PIECE ______ HRS.	PIECE		
DAY ______ HRS.	DAY		
RATE ______ PER HR.	TOTAL		

Fig. 7. — Time Clock Card.

the engineering department for its information. Inventory records of the stores department might go to the superintendent

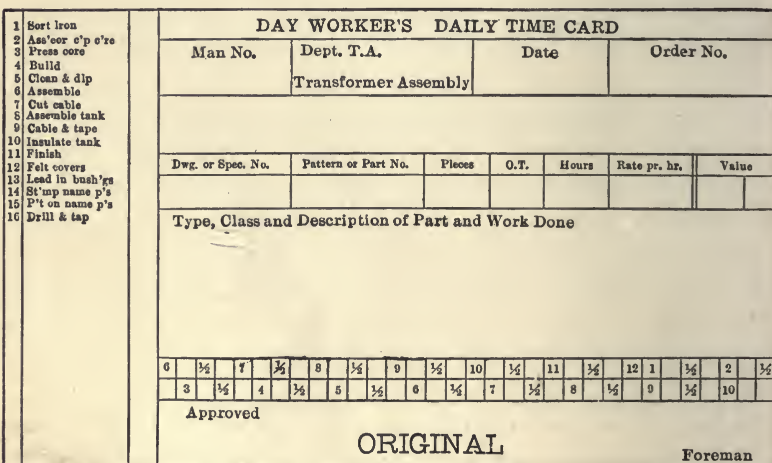
(Fig. 4) or to the order department. All cards recording time and material used or indicating progress of work would be returned to the cost department. Fig. 7 illustrates a typical time card on which the time of entering and the time of leaving the factory may be filled in on a time recorder, while Fig. 8 shows a work card giving in detail the time expended on a certain piece of work.

These detail returns are, or at least should be, used for three purposes.

(*a*) To record the results of operations.

(*b*) To predict future operations.

(*c*) To serve as the basis of managerial reports.



1 Sort iron
2 Ass'eor c'p o're
3 Press core
4 Build
5 Clean & dip
6 Assemble
7 Cut cable
8 Assemble tank
9 Cable & tape
10 Insulate tank
11 Finish
12 Felt covers
13 Lead in bush'gs
14 St'mp name p's
15 P't on name p's
16 Drill & tap

DAY WORKER'S DAILY TIME CARD

Man No.	Dept. T.A. Transformer Assembly	Date	Order No.

Dwg. or Spec. No.	Pattern or Part No.	Pieces	O.T.	Hours	Rate pr. hr.	Value

Type, Class and Description of Part and Work Done

6		½		7		½		8		½		9		½		10		½		11		½		12	1		½		2		½
	3		½		4		½		5		½		6		½		7		½		8		½		9		½		10		

Approved

ORIGINAL

Foreman

FIG. 8. — WORK CARD.

Thus the engineering data from the test floor serves not only to verify the accuracy of the design but furnishes information for future designs. The time and material cards returned to the cost department furnish data for finding the cost of the product and also for predicting future costs. These features will be more fully discussed in succeeding chapters.

These first two functions of the factory returns enable the several departments to do their work properly and to keep track of all that occurs in which they are severally interested.

It is difficult, however, for the manager to obtain from departmental records a clear idea of what is occurring unless these records are presented to him in the condensed form of analyzed **reports.** The written report replaces the old-time manager's personal observations with accurate statistics, and is practically the only way a manager can accurately gauge the operation of a large factory and keep a firm grasp upon it.

The character of the reports that a manager may require depends, of course, on the nature of the industry and the form of organization, and it is not easy, always, to select the reports that will be of most value. Unless reports are of *use,* unless they tell something bearing on the cost of production or similar important features they should be discontinued, as they are a source of waste. Conversely, unless a useful report is used, unless it is the basis of analysis or discussion which throws light on the problems of the business, the data which it presents might as well go into the waste basket. There are certain reports, that will be discussed for the purpose of illustration, which are applicable to nearly all manufacturing enterprises. In Fig. 4, for instance, the president would call upon each vice-president for certain reports from each primary department thus furnishing him with sales, engineering, manufacturing and financial reports. These are typical classes of reports though it may be desirable to have several reports from each department on different phases of its work.

The most important perhaps of all the reports is the **profit and loss statement** which is usually made up monthly by the accounting department and hence is a financial report. This report is a summarized statement of all debits and credits, classified so that the sources of profit or loss can be easily located. The report should show on the debit side all such items as:

(*a*) The factory cost, by classes, of all goods shipped.

(*b*) The cost of delivery of product, including freight cartage, etc.

(*c*) The selling expense carefully classified.

(*d*) The office and general expenses classified and distributed against each branch as far as possible.

(*e*) All other general expenses, such as advertising, insurance, postage, etc.

It should show on the credit side:

(*a*) The selling price of all goods billed.

(*b*) Other miscellaneous receipts, such as rent and interest from outside investments.

The summarized difference of the debit and credit sides shows whether the factory is running at a loss or gain. The importance of the profit and loss statement to the manager hardly needs comment. If properly arranged it is an invaluable index of weakness or strength and from it he should be able to tell just what must be done to better conditions whether that be an increase on sales or a decrease in manufacturing costs.

The returns that flow into the cost department and other departments under the factory manager may be the basis of many reports; and here, again, discretion must be used in selecting those that will be most useful. Only a few important ones will be noted. The **weekly labor report,** as illustrated in Fig. 9, is a classified statement of all expenditures for labor. It enables the manager to see at a glance where the money paid in salaries has gone and to check excessive expenditures. Sometimes a statement is made in this report of the total amount of money expended for material and supplies as well as a statement of the value of shipments. This widens the scope of the report and adds to its usefulness. The **special cost report** is a detailed statement of the labor, material and other expense items which go to make up the cost of a particular piece of apparatus. It is usually compiled for the purpose of making a study of such a piece of apparatus with a view of cutting down the manufacturing expense.

A most useful report is the **progress report.** This may be compiled by the order department, if it is charged with the duty of moving the work through the factory, or it may be a composite report made up from the records or statements of the several foremen. It is of particular value in finding out what contracts and orders are behind schedule time and why this is so. It also furnishes an accurate statement of the volume of unfinished work in the shop.

LABOR REPORT.
STANDARD MANUFACTURING CO.

Week Ending ______________ 19____

DIRECT LABOR.

A.- Alternating Dynamos (Complete Machines only).
B.- Arc " " " "
C.- Direct Current " " " "
E.- Mining Apparatus " " "
F.- Railway " " " "
G.- Stationary and Synchronous Motors (Complete Machines only).
I.- Cutouts and Switches.
K.- Meters and Measuring Instruments.
M.- Transformers and parts thereof.
O.- Miscellaneous Supplies of our own manufacture.

SUNDRY PARTS AS FOLLOWS.

Q1.- For Alternating Dynamos and Motors.
Q2.- " D.C. " "
Q3.- " Stationary and Synchronous "
Q4.- " Railway Generators and "
Q5.- " Induction Motors.
R1.- Arc Lamps.
R2.- " Lamp, Parts and Supplies.
U.- Induction Motors (Complete Machines only).
W.- Switchboards (Complete).
Scrap.

TOTAL DIRECT LABOR.

(Average Rate Per Hour, Direct Labor). ____________)

INDIRECT LABOR.

Salaries Superintendence.
Cost Dept.
Time Keeping.
Production Dept.
Factory Supt's Clerks.
Shipping.
Foremen and Inspectors.
Watchmen
Engineers and Firemen.
Oilers and Sweepers.
Helpers, Laborers and Messengers.
Stock and Tool Room Employees.
Testing. " " "
Trucking, Transportation, Elevator and Crane Men.
Gatemen.
Miscellaneous Expenses.
Repairs to Buildings (including small shop construction and wiring jobs).
" " Machinery and Tools (including setting up of same).
" " Patterns.
" " Shop Furniture and Fixtures.
" " Defective Apparatus.
" " Rolling Stock and Horses.
Expense Tools.
Boxing and Packing (time consumed in packing finished apparatus for shipment).
Clerks of Foremen and Inspectors.
Receiving Room Employees.

TOTAL INDIRECT LABOR.

(Average Rate Per Hour, Indirect Labor). ____________)

PROPERTY AND OPEN ACCOUNTS.

Real Estate and Buildings.
Machinery and Tools.
" " Catalogued.
" " Uncatalogued.
" " Special Tools.
" " Power Plant Equipment.
Shop Furniture and Fixtures (including Machinery foundation).
Office " " "
Experimental.
Draughting and Designing.
Engineering (for Factory.)
Development.

TOTAL PROPERTY AND OPEN ACCOUNTS.

(Average Rate Per Hour, Property and Open Accounts). ____________)

Remarks.

Date Signed

FIG. 9. — WEEKLY LABOR REPORT.

The **reports from the sales** departments would, of course, show actual sales by territories and a corresponding statement of the expenses incurred in making sales. In addition, the thoughtful salesman can greatly aid the manager by reporting competitive prices, engineering or manufacturing data; in fact, anything that will keep the management informed of what is transpiring in the salesman's territory.

Engineering reports are usually of a technical character and are intended to keep the manager informed on the engineering features of the business. They may also take the form of circulars of information to salesmen.

47. Interpretation of Reports. Statistical statements can often be made much more effective by combining or contrasting them, and it is often necessary to consider data from different reports to obtain best results. Thus it may be important to know the value of the output for a given period; but it is, in general, much more important to know the output *per unit of capital invested.* Again the amount of coal consumed in the power plant per month might be of interest, but the coal *per kilowatt-hour* is a much closer check on the efficiency of the power plant. All statistical data gain in importance by *comparison.* Thus the coal per kilowatt-hour as an indication of the efficiency of the power house gains in value by comparing it with the record of preceding months, with a view of seeing how near it approaches the best record. And even this comparison is made more effective and searching if, at the same time, account is taken of the load factor month by month.

Comparisons of this sort are facilitated by expressing the data in graphical form which not only shows more clearly the relative values of any given account, from date to date, but shows the relative values of different sets of data, as well as indicating *tendencies* much more clearly than can be done by tabulated figures. Fig. 10 shows a few curves such as might be plotted from the records of a plant employing about 1200 men and turning out $1250 worth of product per capita per annum or a total of $1,500,000 per annum at factory cost. The curves shown are hypothetical and do not represent any actual case. They

serve, however, to show the general character of such curves. Other curves, of course, may also be plotted if they will assist the analysis. Thus, the curves of material used might be of interest and, if the factory was developing new machinery, the

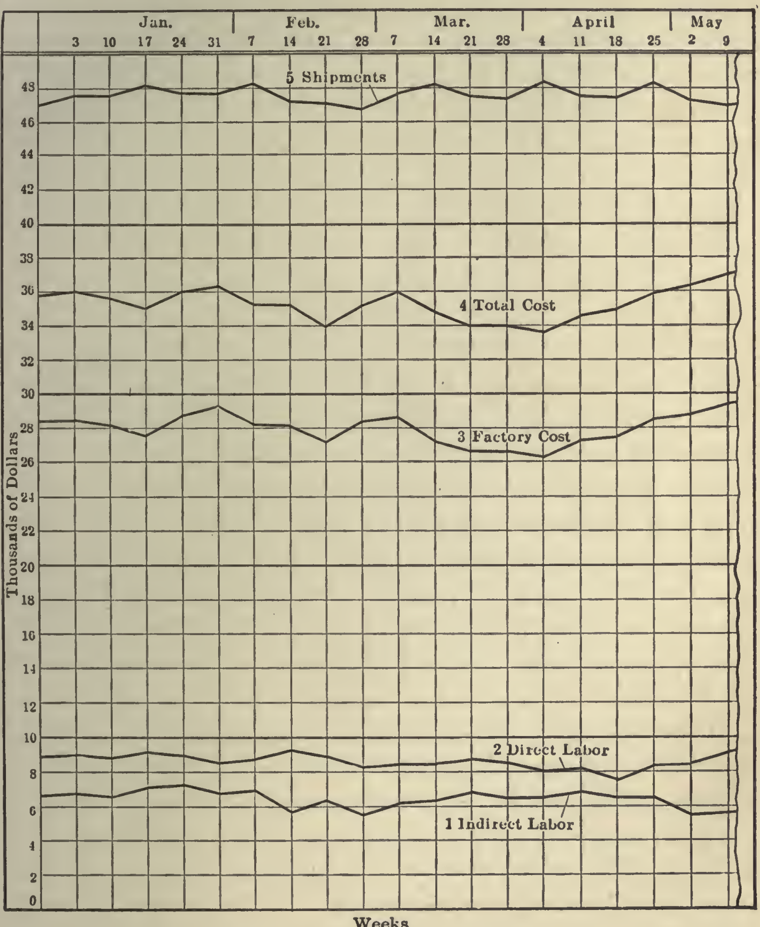


FIG. 10. — GRAPHIC REPORTS.

cost of experimental work would certainly be an important account. If the product were diversified it might be desirable to plot separate curves for the several lines of goods manufactured, combining their totals into curve number 3. Curve 3

represents the total shop cost of all goods manufactured while curve 4 shows the total cost of goods including all general and selling expenses. The difference between curves 4 and 5 will be the probable profit for the week considered, but does not indicate what the profits will be on the particular goods shipped during that week. Sometimes it is useful to plot the *average*[1] values of the account considered and again it may be helpful to plot the *accumulated total* up to the time considered depending on the business and the information needed. The principle is of very wide application and helpful in all cases where large masses of detailed returns must be condensed into a form that will indicate general tendencies at a glance.

The Committee System.

48. Committees in General. Factory problems are nearly always many sided and hence difficult of solution by any one man, especially where, under staff organization, he is charged with and capable of handling only one phase of the work. Furthermore, as before stated, when several men are on the same authoritative level there must always be some definite means provided so that they can harmonize their efforts. There is no way by which these ends can be served comparable with a good committee system. There are several inherent advantages in a good committee. First it is impersonal in its action, and its verdict, like that of any jury, is usually based on the *facts* presented. The very atmosphere of a committee tends to compel all of its members to lay aside pettiness and personal prejudice and to act in accordance with the merits of the case. The foreman who would, over the telephone, blame a fellow foreman for a delay will hesitate to do so in his presence or in that of his superior officers. The decisions of a committee are, therefore, likely to be more accurate than those of an individual because of the greater accuracy of its basic information. A misstatement on the part of a member is not likely to go unchallenged.

Secondly, committee meetings tend to promote a better un-

[1] For a more extended discussion, see Works Management, by W. D. Ennis, p. 17.

derstanding between men of the same authoritative level and of different levels. Distrust and jealousy of each other are rapidly eliminated as men know one another better and see the good side of each other's nature. There is something likeable in all men if one can succeed in discovering it, and this can be done only by bringing them into close personal contact with common problems to be solved, not by wrangling and fault finding but by an earnest endeavor to find the very best solution. Thirdly, the committee method tends to awaken interest in the work and to draw out the best efforts of all of its members, and tends generally toward a better *esprit de corp.*

Committees are always of an *advisory* character. They cannot replace strong personality but they can be used effectively to assist a strong executive in finding out what is actually going on in the factory, in deciding what should be done, and in enlisting the good will of those under him. The best and most natural basis of committee work is a report on the matter under discussion, and reports are greatly enhanced in value when discussed by an intelligent and representative committee. There may be many kinds of committees and for many purposes, but only a few typical ones will be discussed here. In general, committees should not be too large or too small. If too large they become very unwieldly and if too small they may not secure a broad representation. A committee of six members is usually large enough.

49. The Manufacturing Committee. Referring to Fig. 4 it is apparent that no one of the four vice-presidents would be able, in general, to advise the general manager on the entire manufacturing policy of the works. But if these four men are collected into a **manufacturing committee** each of the four important divisions of the works is represented by an expert. The general manager would be the natural chairman and such a committee, through him, can direct the manufacturing policy of the plant with great intelligence. The matters that naturally come before this committee are:

(1) The general manufacturing policy of the plant, the character and sizes of the articles to be made.

(2) The approval of all orders of extraordinary character and the approval of orders for stock, if goods are manufactured for stock. The approval of all extraordinary manufacturing expenditures and recommendations for economies.

The reports that would naturally be laid before it would, therefore, include the profit and loss statement, stock and sales reports and similar general statements.

50. The Tool Committee. The tool committee (Fig. 4) will usually consist of the tool designer, if one is employed, the head toolmaker, a representative of the superintendent's office and any other men from the shop or elsewhere who may be of service in the work under discussion. This committee would discuss all problems concerning tools for new work or improvements in those existing. The amount of money that it is desirable to spend on tools may often be limited by the manufacturing committee, and the tool committee must, therefore, have full knowledge of the number of parts to be manufactured and the probability of a repetition of the order. A tool committee can save or waste a lot of money, and which of these they succeed in doing will depend to a large extent on how closely they consider the effect of the number of parts to be made (See Article 21).

Where it is desired to reduce the cost of manufacture of an existing line the engineer in charge of that line should sit with the committee. The combination of an engineer, a toolmaker and a good manufacturing foreman provides a powerful method for reducing costs so far as tools and design will permit. The special cost reports, already referred to, are a great aid to such a committee when discussing cost reduction. This committee can also be of great help to the engineering department in standardizing product.

51. The Shop Conference. The shop conference is usually composed of shop foremen or similar men and a representative of the order department, with the superintendent as chairman. Before this committee come all problems and questions regarding work in progress, in fact, its minutes are sometimes used as a progress report. If a progress report is maintained by the order department it naturally forms a basis of discussion for the

committee. All matters pertaining to the operation of the shop may very profitably be discussed by this most important committee and the information gathered from the men actually in touch with the work is of great importance, since it will cover the whole range of shop operation, including labor difficulties.

52. Other Committees. The above committees consist, largely, of the officers of the company, but there are many other forms of committees that may well include some of the humblest workmen as, for instance, the **complaint committee** for adjusting differences, the **suggestion committee** and **committees on welfare work.** The principle is of very wide application. Whatever the committee may be, its members should be selected with care, its function should be definite and its meetings usually should be called at regular stated periods. Careful minutes should be kept of its proceedings and careful attention should be given to its recommendations. If properly organized and conducted there is no other method that can compare with a committee system for finding out what is needed and how best to accomplish the needed result. As a means of strengthening executive control and at the same time retaining the good will of the entire organization it is invaluable. Committees, however, like all other machinery of management, must be used with discretion and intelligence. Obviously, the number and character of the committees necessary or desirable will depend on the size and character of the business. The committee system that will be a perfect success in one plant may be useless in another; and in small plants a committee may be a detriment and a waste of time.

53. Departmental System. The foregoing is a very brief outline of the more important features of the systematic control and coördination of the departments of a factory. Each of these departments, again, will have its own *internal system* of card indexes, filing cases, blank forms, etc. In the succeeding chapters some of the detail work of several of the departments will be discussed in so far as it bears on general principles of organization, but no effort will be made to discuss departmental systems in detail since, obviously, they vary so widely as to

make this of doubtful value, especially as such detail is of peculiar interest to the department specialist only. For such detail the student is referred to the many works on office systems.

References :

Shop Management, by F. W. Taylor, Trans. A.S.M.E., Vol. 24.
Profit Making Management, by C. U. Carpenter.
Modern Organization, by C. D. Hine.
Efficiency, by Harrington Emerson.
The Twelve Principles of Efficiency, by Harrington Emerson.

CHAPTER VIII.

PLANNING DEPARTMENTS.

54. General Principles. The separation of mental and manual processes, and the application of the principles of transfer of skill and thought carry with them the principle of preplanning of the work concerned. The convenience and economy of planning work in advance are obvious and need no discussion, and the application of the principles discussed in the preceding paragraphs are well shown in the operation of existing planning departments, such as the engineering department and the tool room.

Planning of work may be done in one of two ways, namely, **empirically** or **statistically.** Any man highly experienced in a given line of work can easily plan a desirable sequence of operations for a given piece of work basing his predictions on his experience and judgment, but there will be definite limitations to the accuracy of his predictions. For instance, if there are several desirable ways of performing the work he will not, in general, be able to say which is the best way, unless he or some other equally competent man has tried them all and recorded his results. Again, he may be able to assign the approximate time necessary to perform the work, or the tools that are most efficient for the purpose; but, in general, unless he possesses *recorded data* bearing on these matters his empirical estimates are approximate only, and his predictions useful only within the range of his experience. Where recorded data are to be had, however, the basis of prediction is much more sound; and if such data form a record of high-grade performances they are inestimably superior to empirical estimates. The engineering and drafting department is the finest example of the separation of mental and manual processes and the prediction of results on the basis of recorded data. True, a considerable amount of

the work of this department is still empirical, and will remain so for many years; yet the progress that has been made is remarkable and foreshadows what may be expected to occur in the planning of manufacturing operations when a sufficient volume of data bearing on capacities of machines, forms of cutting tools, the times required for operations, etc., have been collected.

The growth of the planning department is of interest. A few years ago a typical organization of a production[1] department consisted of the superintendent, the several foremen and a few special officers, such as a stores-keeper and time-keeper. The superintendent received the formal order and instructions for the work, gave it a number, letter or some other distinguishing mark and sent each foreman an order instructing him how to proceed with his part of the work, trusting to natural coöperation among the foremen to keep the correct sequence of operations so that the finished product would be shipped in time. A record was kept of all time and material expended on the job[2] and the *total* cost of the work recorded, though, in general, detail costs were not obtained.

As the necessity of more detailed costs became greater, and the science of cost keeping grew, the instructions or **production orders** (Fig. 6) issued to the foremen were made more and more in detail for each job. As works increased in size it became in-

[1] Properly speaking the production department embraces all men and departments that have to do with actual production, as distinguished from the other general divisions, sales and finance. Engineering though a productive process has become so important in some industries that it is often considered as an independent department, and the name production department limited to that portion of the organization that is controlled by the factory manager (Fig. 4). The name is sometimes applied to the factory planning department but this use of the term does not seem to be warranted. The factory planning department is a part of the production department.

The stock room and shipping department strictly speaking are not productive departments but they are so closely identified with production that they are often included in the production department.

A distinction should be made between *stock* and *stores*. Stock refers to finished parts or finished machinery; stores to raw or unworked material.

[2] The writer does not feel that any apology for the use of this term is necessary. True, it is more expressive than elegant, but, like the term "boss," there is no other word that can be used to take its place fully.

creasingly difficult for the foreman, and others charged with the production, to keep the proper sequence of operations on a *mental* and *verbal* basis; and when one considers the complexity of the modern shop, and the immense number of small parts passing through even a fair-sized establishment, the performance of some of these superintendents and foremen seems marvelous indeed. The demand for a more systematic method of carrying the work through the shop gave rise to the second function of the planning department, namely, that of **scheduling** the work so that a better and more definite sequence could be observed. In the beginning this scheduling was by departments only, but now, in some establishments, each and every operation is scheduled, the machine, and sometimes the man concerned being predetermined. In order to insure the carrying out of a prearranged program of work a **tracing** system naturally grew up and this forms the third important function of a planning department. Summarizing, therefore, the fundamental functions of a planning department are:

(1) Making and issuing of production orders in proper detail.

(2) Scheduling the work so as to secure proper sequence.

(3) Insuring the correct sequence by tracing progress of work.

(4) Collecting such records of performance as may be necessary.

In most instances, the work of the planning department is confined to the first function, but the last three are rapidly becoming important and necessary parts of productive processes. On the other hand the planning department may, and often does, include other functions. A recently published description of a plant where so-called scientific management has been installed lists the following men as under the planning department — shop engineer, stores-keeper, cost-clerk, shipping-clerk, receiving clerk and inspector, as well as several others *directly* engaged in planning. In a small concern it is not only feasible but may be good management to include all these activities under one department. It is, however, contrary to the elementary principles of division of labor, which assigns as few duties as possible, either to a man or a department, these duties being of a *similar*

character as far as possible. The function of the planning department is the planning and scheduling of the work, and as plants increase in size such dissimilar functions as some of those listed above naturally tend to become independent departments functionalized under the superintendent. They are in reality more highly specialized functions that he formerly was expected to perform himself, and the manner of their formation will depend, to a large extent, on the size of the works and the character of the men obtainable for the several positions. Thus both costs and rate setting might very well be included in the work of the planning department and not be, as indicated in Fig. 5, directly under the superintendent. On the other hand there seems to be no good reason for making the planning department an independent one under the factory manager (if there be one), thus making the manager of the planning department a thorn in the side of the superintendent who is charged with the responsibility of production. The planning department should be in charge of the superintendent of production, and the head of the planning department should be of the character of an assistant superintendent. When organized independently it usually results in much duplicate work and opens up an opportunity for inter-departmental bickering.

55. Functional Foremanship. Many existing industrial plants have well-defined planning departments performing one or more of the four fundamental functions noted above. Mr. F. W. Taylor[1] has very ably shown that the work of planning may be very greatly extended and at the same time greater advantage taken of the principle of the division of labor. His typical organization, which is outlined below is particularly adapted to iron-working establishments machining large pieces, but the principles involved are of almost universal application. Under Mr. Taylor's system the work now ordinarily performed by the

[1] See "Shop Management," by F. W. Taylor, Trans. A.S.M.E., Vol. 24. This classic paper should be read by everyone interested in industrial enterprises. Whether all the methods advocated by Mr. Taylor are desirable or not the fact remains that the principles advanced will increase production if intelligently applied and the paper no doubt indicates the trend of industrial organization.

foreman is divided into several parts or "functions" each performed by a separate **"functional foreman"** or **"functional boss"** as he styles him. Care is taken to separate *planning functions* from *executive functions* and all planning is removed, as far as possible, from the shop to the planning department. The latter then performs for the *constructive* side of the industry what the engineering department has long performed for the *designing* side of the work. In fact, the movement to do the planning of all productive processes in advance and in a separate department is analogous to the movement that formed the engineering department. It is in strict accord with the general principles of division of labor and the separation of mental and manual processes.

In his work at the Bethlehem Steel Company Mr. Taylor found the following subdivision[1] and rearrangement of functions profitable: —

In the Planning Department.

(1) The Order-of-Work or Route Clerk.
(2) The Instruction-Card Clerk.
(3) The Time and Cost Clerk.

In the Shop.

(4) The Gang Boss.
(5) The Speed Boss.
(6) The Inspector.
(7) The Repair Boss.

And for the Entire Works.

(8) The Shop Disciplinarian.

The following is a very brief statement of the duties of these several bosses as stated by Mr. Taylor:

The order-of-work or route clerk lays out the route that the piece is to follow through the several shops and the sequence of machines and men that are to operate upon it in each shop. He

[1] Mr. Taylor's analysis of the duties of the average foreman and his use of this analysis in subdividing the foreman's functions is a masterpiece that will repay reading. See A.S.M.E., Vol. 24.

prepares the **route sheet** and from it he, or his assistant, makes out the **work orders** for each man or machine operating upon it. These work orders usually give a list of the materials required for the work specified, describe the work to be done and indicate where the piece is to be sent for the next operation. The work order is the production order of Fig. 6 more highly developed. It must give also the order number of the job, the number of the instruction card (to be described) or other references which may be needed to identify it. The order-of-work or route clerk is responsible for the sequence of work in the shop, though in some modified applications of Mr. Taylor's system both a route clerk and an order-of-work clerk are used, the first laying out the route schedule and the second seeing to its operation and enforcement. This division would naturally come about in a large plant, but even then these two men must work in close harmony.

The instruction-card clerk fills out the **instruction card** (Fig. 11) which bears the same relation to the planning department that a drawing does to the drafting room. It gives all the information regarding the necessary drawings, order numbers, jigs, fixtures, etc., and gives the exact sequence of detail operations that must be followed by each workman. It may give the number of cuts, the depth of each cut, the speeds and feeds and the time each cut and operation should take. It may also give full information regarding the piece rate, day rate, or premium on which the work is to be performed. In certain cases it is clear that it might include the information listed on the work card just described, but usually it is more convenient to use the two cards.

The time and cost clerk prepares for the instruction card the necessary instructions to the workman for the recording of time and cost of all work and for securing from the workman the proper returns for making cost and time records (see Article 46).

The gang boss makes all preparations for getting the work to the workman, collecting the necessary jigs, drawings, etc., and sees that the work is properly set in the machine. He relieves the workman of all preliminary planning as far as placing the piece in working position is concerned.

NO. *162*

INSTRUCTION CARD

ORDER NO.	DRAWING NO.	PART NO.	NO. OF PIECES	MATERIAL	MO.	DAY	YEAR
.02346	*467*	*2A*	*40*	*#3 C.I.*	*6*	*8*	*1912*

MAN'S NAME	MACHINE	SPEED BOSS
Wm Jones	*Lathe 176*	*John Tracey*

	INSTRUCTIONS	TOOL	CUT	FEED	SPEED	PIECE TIME	LOT TIME
1	*Preparation*						*200*
2	*Set fixture*	*246C*					*200*
3	*Set piece in fixture*					*030*	
4	*Rough face*	*F2*	*.15″*	*.05″*	*H 3*	*250*	
5	*Change feed and speed*					*002*	
6	*Rough bore*	*B6*	*.06″*	*.08″*	*G 2*	*300*	
7	*Ream*					*080*	
8	*Counterbore*	*C3*				*016*	
9	*Stop machine and take*						
10	*work out of fixture*					*018*	
11	*Clean fixture*					*004*	
12	*Change speed and feed*					*002*	
13	*Clean Machine and*						
14	*Change work order*						*150*
15							
16	*Add 10% to piece time*					*070*	
17							
18							
	TOTALS FOR ONE PIECE					*772*	*550*

TOTAL TIME FOR *40* PIECES = *772 x 40 + 550* *31.43*

TOTAL TIME ACTUALLY TAKEN FOR *40* PIECES *30.20*

WHEN MACHINE CANNOT BE RUN AS SPECIFIED REPORT AT ONCE TO *M. T. Mason*

SIGNATURE OF SPEED BOSS *John Tracey*

FIG. 11. — INSTRUCTION CARD. Hand-written Instructions are Indicated by *Italics*.

The work of the speed boss begins after the piece is set in the machine. He sees that the right tools are used and that the feeds and speeds are according to instructions. He also instructs the workman in the best method of doing the work.

The inspector is charged with the duty of seeing that all work is up to standard in workmanship and finish.

The repair boss has charge of all machines, belts, etc., and sees that they are kept in good order and repair.

The shop disciplinarian is responsible for discipline and good order. He is also the peacemaker and assists in adjusting wages. He represents the disciplinary functions formerly executed by the foreman.

This rearrangement of duties virtually amounts to the replacing of practically all line organization below the superintendent with staff organization.[1] It is evident that the extent to which such a reorganization can be carried in any plant will depend upon the size of the plant, the character of the product, the personnel of the staff and last, though by no means the least, the amount of statistical data bearing on productive processes that is available as a basis for planning the work. The possibility of successfully making such a redistribution of duties and of securing the manufacturing advantages that should follow this extended division of labor depends also on other factors that introduce new needs, including new methods of rewarding labor.

56. Forming the Instruction Card. In order to be able to prepare a machine-shop-work order and an instruction card as shown in Fig. 11 the following information regarding the work in hand must be available in convenient form:

(*a*) Complete detailed drawings and other engineering information.

(*b*) Complete information regarding special tools, such as jigs and fixtures, whether existent or to be provided.

(*c*) Complete information on lowest costs of previous performances.

[1] The student will find it a useful exercise to rearrange Fig. 4 to conform to Mr. Taylor's subdivision of duties.

(*d*) Accurate up-to-date information regarding the raw and finished stock that is to be used.

(*e*) Exact knowledge of the progress of the work in process.

(*f*) Complete tabulated data on power, speeds and feeds of all machines.

(*g*) Complete data as far as can be obtained on the most effective forms of cutting tools and the best combinations of speeds and feeds for the metal to be cut.

(*h*) Records of the best performances on similar work with best combination of tools, feeds and speeds.

And to insure the attainment of the performance predicted on the instruction card there must be:

(*i*) Careful instruction of the workmen by the speed boss or some similar person.

(*j*) Careful following up and correction of the shop schedule.

(*k*) Careful inspection of all tools and appliances to make sure they are up to standard conditions.

(*l*) A financial incentive that will enlist the interest of the workman.

Brief reflection will show that similar conditions and requirements apply to other forms of industry, the principles being capable of wide extension.

Of these requirements several are now fairly well met in many modern shops. Thus (*a*) presupposes a first-class engineering and designing department, (*b*) a well-developed tool room, (*c*) a first-class cost system, (*d*) an accurate continuous inventory system, all of which have reached a high state of development in many plants. The remaining requirements, however, are in a rudimentary stage in most shops and it may be of advantage to discuss them briefly.

57. Order-of-Work Methods (Item *e*). It is evident that if work is to be accurately scheduled through a works of any magnitude, it must be accomplished by written orders and by systematic methods. The most usual method of accomplishing this result in a machine works is somewhat as follows: An order box containing say four compartments is placed near each workman. The upper compartment holds the instruction card, order-

of-work card, etc., for the job in process; the next lower compartment contains the instructions, etc., for the next job for which the gang boss is collecting or has collected the tools, jigs, etc.; the third compartment may be used to hold instructions for future work, the sequence of which has not as yet been determined, and the lower compartment may be used for suspended jobs on which work has been discontinued temporarily. In the office of the planning department is placed a "route rack" or "schedule board" containing groups of pockets that are duplicates of those in the shop; each pocket containing instruction cards that are duplicates of those in the corresponding pockets in the shop. When the instructions are moved in the shop from one compartment of the order box to another or from one machine to another, the corresponding change is made on the office route rack so that the route rack always shows the exact amount of work before each man or machine. The order-of-work man must keep fully informed of the desired dates of delivery of all orders and of any change in such dates. By means of the route rack he can fully control[1] the sequence of operations and make estimates of the time required to complete work in process or new work on which such an estimate is desired. Fig. 12 shows the schedule board of the Tabor Manufacturing Co. of Philadelphia. Here three sets of hooks are used for each production center, the upper hooks of each set holding the order for the work in process.

58. Data on Machines (Item *f*). It is evident that before the instruction card man can intelligently instruct the workman regarding the size of cuts and feeds and speeds to be used, very complete data must be compiled bearing on the cutting power and the speeds and feeds obtainable with each machine. This information is not available in most shops and must be collected. It is also evident that this would be much simplified if all machines of the same kind were made along standard lines. At present a machine of given nominal size made by any given manufacturer is usually very different in its characteristics from those

[1] See Report of Conference on Scientific Management at Tuck School of Commerce, p. 365.

Fig. 12. — The Schedule Board of the Tabor Manufacturing Co.

of rival makers. These new methods will undoubtedly have some effect tending to standardize tools of all kinds.

59. Data on the Art of Cutting Metal (Item *g*). It would most naturally be supposed that an experienced skilled workman would know more than anyone else regarding the best shapes of cutting tools and most efficient combinations of feeds and speeds for the work of his particular calling. In simple trades this, or corresponding data, may be easily obtained, but, in general, the information possessed by the mechanic is empirical and based on inherited[1] practice that is never questioned by him. All trades and callings abound in practices that are transmitted downward with almost superstitious exactness and with little or no thought as to whether a better way cannot be found. This is very well instanced in the case of cutting of metals. Here (according to Mr. F. W. Taylor) there are twelve variables involved and it is evident that no man can carry in his head the best combination for any given case. Actual experience has shown this to be so, and has demonstrated that the best combination of these variables can be found much more accurately by mathematical analysis than by the best empirical knowledge. A full discussion of this complex problem is beyond the scope of this treatise.

A considerable amount of general information on this subject has been collected[2] from time to time but the most comprehensive attempt to solve this problem was that made by Mr. F. W. Taylor and recorded in full in the Transactions of the American Society of Mechanical Engineers. (Vol. 28 year 1907.) Mr. Taylor's experimental work and the laws that he deduced therefrom were reduced to mathematical expressions by him and his assistants. The complexity of the problem will be appreciated when it is considered that no less than twelve variables are involved. By means of very ingenious slide rules,[3] however, Mr.

[1] One of the best instances of the empirical development of an almost perfect tool is found in the common ax and ax handle. It would have been difficult indeed to analyze this problem and design the modern ax scientifically.

[2] See also Profit Making in Shop and Factory Management, by C. U. Carpenter, pp. 86-91.

[3] See Trans. A.S.M.E., Vol. 25, p. 49.

Carl Barth succeeded in making these expressions usable and with these slide rules the most efficient combination of speeds and feeds are quickly obtained. Mr. Taylor's work did not cover all kinds of metals and there is still much to be done in other lines of work before information of this kind is common; yet aside from the actual results obtained the principles involved are of prime importance and the paper mentioned above will repay reading. Similar investigations are now being made in other lines of work.

60. Standard Performances, Time and Motion Study (Item *h*). What has been said of the average workman's ideas regarding feeds and speeds is equally true of his judgment of the *time* required to do a given piece of work and the consequent cost thereof. A good cost system, therefore, may give fairly accurate data regarding costs of work accomplished but its records are not necessarily the best that can be made with a given equipment. In times past piece rates, and estimates in general, have usually been made either by judgment on the part of the foreman or the rate setter, if one was employed. Occasionally trial performances are made to find a satisfactory basis. The inaccuracy of the first-named method of setting rates and the troubles arising therefrom will be more fully discussed in connection with a discussion of systems of rewarding labor. Such methods could, of course, still be used as a basis of creating the instruction card, but Mr. Taylor has pointed out (Trans. A.S. M.E. Vol. 24, p. 1423) a much more accurate method of finding what length of time *should* be required for any job with given equipment and conditions. In this method accurate measurement is made of the time required to do the several detail parts of a given operation. This detail subdivision is often made quite minute so that the observation must be made with a stop watch. Observations are made of many repetitions of the same detail operation as performed by several of the best and most rapid operators and the lowest observed time or "unit time" becomes a **standard of performance** for that operation and may be used in filling out an instruction card for a repetition of the operation, either in connection with a similar piece of work, or

in connection with a different piece of work, provided the detail operation is the same in each case. The observations are, naturally, taken from the most rapid operators and can be used as standards and serve as a basis for setting piece rate or premium methods of rewarding labor. Allowance must be made for fatigue and rest and some progress[1] has been made in recording data bearing on the relative amount of rest that must be allowed for various kinds of work. It is evident that the degree of perfection to which the study of unit times may be profitably carried depends largely on the kind of work and the amount of repetition that occurs; but in any case it is evident also that this method of approaching the problem is a great advance over old empirical methods and any rate setter will profit even by its limited use.

The sequence of operations should, of course, be carefully laid out before observing unit times; but a careful study should always be made of each operation while timing it to see if better results can be obtained by changed methods, tools or surroundings. It has long been recognized that more work can be done by a man when the work, tools and surroundings, in general, are *convenient*. Builders of machine tools have long appreciated and applied these general principles in the design of tools, and manufacturers interested in such work as the assembling of small machines made up of many parts have for many years paid considerable attention to the proper division of work and the arrangement of parts so as to require as little effort and motion on the part of the workman as possible.

These methods, however, have in general been confined to the best examples of mass production and have not been recognized as fully as one might suppose. The work of Mr. Frank B. Gilbreth[2] has very ably called attention to the fact that great gains may be made by systematic **motion study** in all lines of work and particularly in the simpler trades where one would not suppose such possibilities to exist. The elimination of unnecessary motions means less fatigue for the same result, with a consequent greater possibility of accomplishment. A full discussion of this

[1] See Trans. A.S.M.E., Vol. 24, p. 1428.

[2] See Motion Study, by Frank B. Gilbreth.

important principle is beyond the scope of this book, but the subject is worthy of the close attention of manufacturers.

61. Methods of Insuring Performance. (Items *i, j, k, l.*) It is clear that if the standard performances are based on records somewhat lower even than the best record they will be beyond the attainment of many of the less skilled workers. It is clear, also, that if the output of the factory is raised to these standards, in general, one of two courses must be pursued. Either the less skillful men must be eliminated and their places filled with better men or they must be *educated* and taught how to raise their performance to the standard. The latter method is, of course, the most humane and in the long run will be the most effective. Mr. H. L. Gantt was the first, the writer believes, to appreciate fully the opportunities of this field and his work and writings[1] on this phase of shop management forms a very valuable addition to the literature of general industrial education.

It is also self-evident that if the planning department is to predict performances that can be successfully executed all machines and tools must be in the first-class condition that the planner must presume them to be. For this reason the inspection, care and repair of all productive apparatus should, if possible, be under one man whose business it is to see to these matters and nothing else. Such a man can earn his salary even in a comparatively small shop. Under such a system matters such as breaking of belts are, in large measure, obviated by pre-inspection and repair, and the same principle applies to apparatus in general.

And last, and by no means least, if the worker is to raise his output to a standard higher than he has been accustomed to he must receive extra compensations for his extra effort. Otherwise he will not make the effort. It has been noted previously (Article 9) that the worker is usually skeptical regarding the effect of increased output. It is useless to point out to him that increased output will tend to help him because of the *ultimate good* flowing from abundant production. The reasoning is usually beyond him; and the only incentive that will move him is

[1] See Work Wages and Profits, by H. L. Gantt.

an *immediate* gain. All efforts to increase production by the above methods usually are, and in fact must be, operated in connection with some method of rewarding labor that gives increased compensation for increased effort. The various methods of rewarding labor are more fully discussed in Chapter XI.

62. Conclusion. The foregoing is a very brief account of the more important tendencies in the planning of factory operations. It should be noted that functional foremanship and similar methods are in no way connected with any particular form of wage system, nor do the methods discussed in this chapter, taken singly or collectively, constitute a complete philosophy or scheme of management that will be best for all cases. The combination and arrangement that will be best to use will, necessarily, vary with the conditions; and what may be good for one place would not apply at all in another. These methods, however, are excellent illustrations of the separation of mental and manual processes, and the use of division of labor, and transfer of skill. The strong coördinative influences necessary for such forms of organization are found in the instruction card and route card, and the incentive of extra compensation for extra effort. Some very complete applications of these methods have been made in this country though, as yet, few complete accounts of such applications have appeared.

Objection is often made, particularly by managers of the older type, to the introduction of any such system as described in this and the preceding chapter on the ground that it adds to the cost of production. This may often seem to be true as most of the men employed in planning and carrying the work through the shop do not work *directly* upon the product. Furthermore there is no doubt that useless and costly system is sometimes installed where the conditions do not warrant, and in such cases the cost of the product is necessarily raised. There is no virtue in system of any kind unless it is installed intelligently and with a clear idea of the results it is desired to obtain.

Usually there is no difficulty in deciding how far it is economical to go in providing system to collect valuable information, as in cost systems, or in system for facilitating the transmission

and use of information that will hasten operations and thereby increase the efficiency of productive processes already existing; but it is not always easy to decide such questions when they involve the separation of productive processes into mental and manual constituents. Functional foremanship, for instance, is based on a somewhat different reasoning than a cost system. A cost system is valuable no matter how large or small the shop may be, although its characteristics might vary with the size of the shop. But all extensions of the principle of division of labor that involve separation of mental and manual processes and transfer of skill necessarily involve a reduction in the amount of time and labor *actually* spent upon the work and an increase in the amount of planning or *indirect* labor expended upon it. Whether such a rearrangement of duties will result in netting a greater output and reduced cost will depend on the quantity to be made and the character of the work; and it is very easy to over-systematize unless these conditions are fully understood. It cannot be disputed, however, that these principles do result in increased output and decreased cost when properly applied; and the manager that does not use them as far as the limitations of his case will allow, simply because he does not believe in system of any kind, is blinding himself to his opportunities. A further discussion of the limitations of these principles is given in Chapter XIV.

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CHAPTER IX.

PRINCIPLES OF COST KEEPING.

63. Need of Accurate Costs. It would seem to be unnecessary to urge the need of an accurate cost system for all industrial enterprises; yet, with the exception of simple processes, cost systems that give results approaching accuracy are not frequently encountered. The reasons for this are many. It is not uncommon that the manager of a large works has grown up with it, or a similar one, from small beginnings. He may not appreciate that the results that he obtained in the smaller shop by virtue of his strong personality cannot be so obtained either by himself or his subordinates in the larger shop with its vastly increased complexity. Unless he has kept fully abreast of the times he will not be informed regarding what a good cost system can do and he will likely object strongly to the added clerical expense incident to securing accurate costs, because he fails to realize the full importance of these results. To many men costs are simply records of work accomplished, the usefulness of which are ended once the goods are billed. It is true that this is a most important feature of cost accounting, but there are other features no less important.

Modern manufacturing is, usually, a complex process, particularly where articles of varying size or character are made in the same works. It is not sufficient to know that the factory is paying as a whole, especially when competition is strong in special lines. It is comparatively easy to determine whether the plant is, as a whole, paying dividends but without the aid of a good cost system it is impossible to form any idea regarding the profitableness of any single line of product. With a good cost system the manager can keep himself informed regarding shop operations *as they progress* and can often avert losses and difficulties, instead of waiting until the work is finished, when remedy will come too late. The absolute need of statistical data

and condensed reports has already been touched upon. Without a good cost system these are not obtainable and the manager is without one of the most powerful aids in administration. If work is to be planned in advance and if correct estimates are required, whether as a basis of securing new work or of insuring that productive costs shall not exceed market possibilities, a cost system is indispensable. This last feature is a most important one and grows more so daily. The custom of estimating costs in advance of production and then insuring that these costs are met in production, or finding out only why they cannot be met, is coming more and more into use as the practice of planning work in advance becomes more common.

The necessity of accurate costs is of prime importance to an industry as a whole. The manufacturer who underbids his competitors on the basis of faulty cost keeping not only works his own ruin but that of his competitors who are bidding on a sound basis. This form of competition is the very worst and should be most feared. It is no satisfaction to the manager whose costs are correct to know that the successful bidder is on the way to bankruptcy, so long as others, no better informed regarding costs, are constantly coming into the field. On a certain boiler installation that recently came under the writer's observation the bids on the boilers ranged from $11.50 to $16 per H. P., the bids on one item of piping ranged from $5244 to $7539 and on another item of piping from $1200 to $4493. The specifications for this work had been drawn with great care and permitted the use of certain apparatus and material only; and, making all due allowance for the lowest bids being as close to the margin of the specifications as possible, the only reasonable explanation of the wide range of the tenders is the lack of knowledge of the costs of production. The necessity of wide publicity of correct principles of cost keeping is obvious, and the successful manager who once offered to send his expert cost man to teach correct cost-finding principles to any competitor was a foresighted individual.

A distinction should be made between **cost keeping** and **bookkeeping** or **accounting** as ordinarily understood. The expert

bookkeeper is interested in costs only as costs. He does not know, usually, in what form these costs should appear to be most effective in reducing expenses or in indicating tendencies, nor in what detail it is necessary to collect shop returns. He is not competent, therefore, as a rule, to lay out the broad features of a cost system. The bookkeeper is interested in finding the facts; the cost keeper wishes to know the *reasons* for the facts. Of course cost keeping must conform to the fundamental rules of accounting, and every cost keeper should be well grounded in these essentials, but the practical shop knowledge, so essential to the successful cost keeper, is very rarely found in the possession of any accountant who has not been trained in cost-keeping methods. For this reason the factory manager should, himself, be well grounded in the principles of cost recording and interpretation and not depend, as is too often the case, on a system built up by his bookkeeper who is probably ignorant of the fundamental principles of manufacturing.

As manufacturing becomes more complex and competition grows more keen, the necessity of accurate costs becomes more and more important. The successful manager of the future will be not only well informed regarding machines and their operation, but he will, of a necessity, be highly informed regarding costs. Until this comes about many managers will continue to sell for less than cost, to declare dividends that, unknown to them, are paid partly from capital stock and to blunder along, penny wise and pound foolish, because of their dread of added clerical assistance.

64. The Elements of Cost. In producing manufactured goods of any kind, by any process, the manufacturer buys supplies which, for convenience, he classifies as raw material. He transforms this raw material into finished product in his factory, adding to its purchase price the cost of the labor expended in the transformation and such other factory expenses as are chargeable indirectly to the operation, in order to find the total cost. The most natural and convenient primary classification of the elements of cost is, therefore, **material, labor** and **expense.** It should be noted, however, that all values with which the manu-

facturer is concerned are in the last analysis labor values. Material becomes valuable, in general, only as labor is performed upon it and its *potential* value, as a natural product, is usually a small part of its value in a fabricated state. All efforts to reduce cost are, therefore, efforts directly or indirectly to eliminate labor values; or in other words to increase the output per labor-hour.

The labor element of cost is usually divided into two classes. All work done directly upon the product and recognizable as pertaining only to the operations upon it is called **direct** or **productive labor.** But all labor around a factory cannot be connected directly with some piece of production. Thus the fireman, the engineer, the oiler, crane men, errand boys, office help, etc., are employed in activities that are *general* and not *specific,* or the time that they are employed on any one job is so short as to make intelligent distribution of their labor uncertain. Such labor is called **indirect**[1] or **non-productive labor.**

In a similar way there are two classes of materials. All material entering directly[2] into the product is usually classed as **direct material.** But, again, there are many other materials used in a factory that do not enter directly into the product. Thus coal, oil, materials for repairs, etc., are all elements of cost chargeable against product, but not going directly into it, nor connected with any one particular piece of work. Such material is called **indirect or expense material.**

Then, again, there are items of **expense** that are neither labor nor material, as, for instance, rent, taxes, insurance, depreciation, etc. These all form part of the cost of production but cannot be connected directly with some particular piece of product.

In computing the cost of production of a given part it is clear that it is possible to allocate the direct labor and direct materials

[1] The terms *direct* and *indirect* are preferable to *productive* and *non-productive.* All labor is, in a strict sense, productive though perhaps not applied directly to any article of product.

[2] There are often material items that enter directly into product that cannot very well be accurately charged against specific pieces of work. Thus nails, screws, glue, etc., enter directly into product but often in such small quantities as to make accurate accounting of them impossible.

chargeable against it; but the indirect labor and material and the expenses, such as rents, etc., are not so readily allocated. These indirect charges are usually gathered together under the general title of "**burden,**" "**overhead expense**" or simply "**expense.**" The total cost of production, therefore, is made up as before noted of labor, material and expense.

Expense, again, is usually divided into two classes, since in general the functions of the manufacturer are two-fold, namely, *manufacturing* and *selling*. (See Fig. 4 and Art. 43.) These functions, however, are not dependent upon each other though they can, and should be, mutually helpful. The selling force is usually an independent organization and the head sales office need not be even located at the factory. On the other hand many factories have little or no selling force, the product being disposed of through sales agencies that are entirely independent organizations. It is important, therefore, that the expenses incurred in selling should be kept separate from those incident to manufacturing. Hence expense is usually divided into **factory expense** and **general expense** so that they may be checked independently and wastes accurately located and the efficiency of each department determined separately.

The several subdivisions of cost and the several steps in their summation may be shown graphically as in Fig. 13. The sum of the direct labor and direct material is known as the **prime** or **flat cost.** The **shop cost,** called also **manufacturing** or **factory cost,** is found by adding the factory expense to the prime cost. This is the summarized cost that the factory manager is held responsible for and includes all items properly chargeable against production *up to and including the delivery of the finished product to the stock room or shipping floor* as the case may be. Here the financial responsibility of the shop manager stops. The **total cost** is the shop cost plus all other expenses such as sales, advertising, salaries of officials, shipping, transportation, etc., incident to marketing the product, and usually designated as **general, commercial** or **selling expense.** To make a profit the product must be sold for more than the total cost and the **selling price** is therefore the total cost plus the profit. The relative propor-

tions of these items will, of course, vary considerably with the character of the work, and the organization of the factory. The figures given in Fig. 13 are hypothetical, but not improbable, for general manufacturing.

It is to be noted that all the items included in the total cost are fixed by the nature of the product and the efficiency of the organization. The profit is, in a way, arbitrarily fixed. It is clear that for a given capitalization and a required percentage of profit thereon, the percentage that must be added to the total cost to make the selling price will depend on the *volume*[1] of the output. If this volume is large compared with the capitalization the percentage added for profit may be comparatively small;

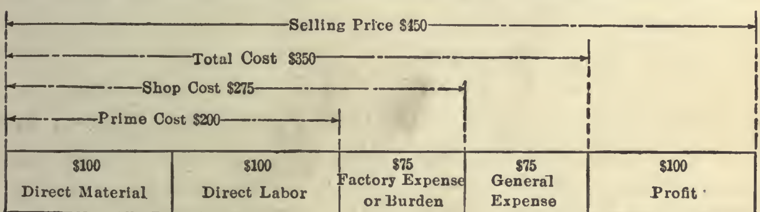

FIG. 13.

if the volume is small as compared to the capitalization the percentage added must be larger. And if this percentage is so large as to make the selling price too high, competition will prevent sales. In such a case the output must be increased in volume or the cost of production must be decreased to obtain the desired profit.

It should be carefully noted, also, that a given percentage on the total sales is not obtained by adding that percentage of the total cost to the total cost. Thus, if the total cost is $75 and it is desired to make 25 per cent on the total sales to give the required profit on the investment, the sales price would not be obtained by adding 25 per cent of $75 to the total cost of $75 since that would give a sales price of $\$75 + \$\frac{75}{4} = \$93.75$ and the difference between the sales price and the cost, or ($93.75 —

[1] The use of statistical data such as the *ratio of output to inventory* is well instanced here. See also Art. 47. Note also that the capitalized value may and often does exceed the actual or inventory value.

\$75) is not 25 per cent of \$93.75. If, however, $33\frac{1}{3}$ per cent is added to the total cost the sales price is \$100 and 25 per cent taken from this leaves the total cost or \$75, hence the profit would be 25 per cent of the sales price and would bear the correct relation to the profit desired on the investment. Care should be exercised that operations involving percentage are based on correct theory, otherwise undetected financial loss is liable to occur. Errors of this kind are more frequent than might be supposed.

65. Classification of Expense. The items that usually enter into the factory expense are those that are incurred in actual production and that cannot be charged directly to some particular piece of work. The items that enter into the general expense are of two classes, namely, **administrative** and **selling expenses.** In many cases it is advisable to record the selling expense separately in order that the efficiency of the selling department may be determined, even though both classes are treated as one in determining selling price. The dividing line between factory and general expense cannot always, however, be sharply drawn because industrial conditions vary so widely. Thus the duties of the president, treasurer and similar officers may include supervision of both manufacturing and sales and their salaries should be distributed accordingly. In some cases the selling and administrative cost may be so small that they can be, without great error, included in the factory expense. In many cases it is desirable to distribute such items as interest, taxes and insurance in the factory expense, while in others it is sufficiently accurate to throw them all into the general expense. The following, however, are representative items of factory expense:

Superintendence.	Rent.
Light.	Insurance.
Heat.	Taxes.
Power.	Repairs and betterments.
Salaries of watchmen, etc.	Depreciation.
Factory office salaries.	Defective material and spoiled work.
Indirect labor.	Experimental (for factory).
Interest,	

As before stated the items that enter into general expense include administrative expenses and those incurred in marketing the product and will therefore include such items as:

Salaries of general officers.	Expense of sales.
Advertising.	Collecting.
Legal expenses.	Accounting.
Correspondence.	General office expenses.

This classification is in general accord with the average practice of skilled accountants. The nature of most of the above-named expenses and the reason for so classifying them are self-evident, but there are a few that will require further discussion. These are interest, rent, taxes, insurance, repairs and betterments, depreciation, defective material and spoiled work, and expenditures on experimental work.

66. Interest and Rent. Accountants and economists are not unanimous in their opinions as to the conditions under which interest should be charged against product. Clearly if the manufacturer rents land or buildings or machinery the rent that he must pay the owner represents a manufacturing expense and is a just and proper charge against product. If now he is manufacturing a varied product with an equipment of varied value, housed in buildings of different character and cost, it certainly is obvious that he should distribute the burden of this rent with reference to the value of his equipment if he would obtain the correct cost of the several lines of product; and the same remarks hold true if his plant is built and equipped with borrowed capital on which he must pay interest.

If, however, the manufacturer *owns* his land and equipment he is under no such obligation and, apparently, need not include a charge for interest on his investment in computing his cost. Nevertheless, there are good reasons why this should be done. Clearly the money that he has invested in his plant would yield him the prevailing market interest if he simply loaned it and made no effort himself to employ it. Or, if invested in land and buildings, it should yield him interest in the form of rent, with no appreciable effort on his part. Unless, then, he takes this

interest factor into account he cannot tell whether or not he is obtaining remuneration for his own exertions or in return for the added risk that he assumes in working his own capital. Moreover, unless he distributes this interest charge in proportion to the value of his equipment he cannot obtain a correct idea regarding what part of his product is paying him the best returns, if his manufacturing problem be at all complex. The counter crediting of such interest charge so that the profit and loss account will show the total profit is a matter of bookkeeping only. Of course the manufacturer that owns his plant has an inherent advantage over the man that rents his plant or capital. The latter *must* make a minimum profit in order to pay his interest, the former not having this limitation.

67. Insurance and Taxes. It is held by some accountants that these items, like interest, are attributes of capital and do not belong in manufacturing expense. Economically this may be true but the object of cost keeping is not to decide points in economics but to *determine costs* and if the plant is complex and the product varied these items should be distributed in the factory costs.

68. Repairs and Betterments. Care should be exercised in charging off the cost of repairs. Obviously, all ordinary repairs and replacements made necessary by wear and tear are chargeable against production. In the case of rebuilding a machine or making extensive improvements upon it, however, it may be allowable to consider the work a betterment that will add to the productive capacity of the machine, and hence creditable to capital or plant investment, the inventory value of the machine being raised accordingly. Care should be used that such betterments really do add to the income-producing capacity.

69. Depreciation. Depreciation and repairs are intimately connected and the former is so important that it is considered justifiable to make it the basis of a subsequent chapter (see Chapter X).

70. Defective Material and Spoiled Work. If a certain class of work is unusually difficult so that bad castings or spoiled work is likely to occur to a much greater extent than in the ordinary

run of work, the extra expense incurred thereby should be charged against the particular class of work concerned, and should be considered as an allocable productive expense. The occasional bad casting or piece of spoiled work should not, in general, however, be charged against the particular job in which it occurs; but the cost of all such items should be distributed in the factory expense thereby distributing the loss over the entire output in the same way as insurance. If this is not done the cost of the penalized job may be excessively and unjustly high. If the spoiled piece is one of a large lot it may be proper to charge off the cost of the spoiled part against the cost of the lot. Lost time, *i.e.*, time paid for but yielding no returns, as in the case of a delay through breakdowns, is of the same general character. Such charges, however, should be entered in the costs as a separate item so as not to cause confusion in making estimates on work where such losses may not apply, thereby raising the estimated cost unnecessarily. It is of as much importance not to have estimates too high as it is to avoid having them too low. One causes loss of business through failure to secure contracts, while the other causes financial loss on the contracts taken.

71. Experimental Work. Experimental work, that has for its object the development of better manufacturing facilities, is obviously a factory expense. Experimental work that is conducted for the purpose of securing engineering data is somewhat different in character. Thus in developing a new line of goods it may be necessary to do a considerable amount of preliminary designing and experimenting. The cost of this may often be carried to a special **development account** and if the preliminary work is consummated by placing the proposed line of goods in production, this development account may be charged off against the product over a predetermined amount of production. If this is not advisable, or feasible, the preliminary work must be charged off in the general expense.

72. The Classified Expense Order-Number List. From the foregoing it will be seen that the relation between factory expense and general expense will vary greatly with the character of the business, its size and complexity. A careful analysis of

these relations must be made, therefore, and a classified list of expenses prepared, covering in detail the cost accounts that are deemed necessary. In a large works these accounts may be numerous, one large manufacturing company in this country dividing its expense items into one hundred and thirty accounts. All work or material not chargeable directly to product must be charged to the proper expense account, and in order to do this each account must be identified by a number or letter. In small works, where great detail is not needed, the mnemonic[1] system of labelling accounts has been found satisfactory. Thus the account for *repairs to buildings* may be marked *R. B.*; expenses for *power, heat and light, P. H. L.* and so on. The use of such symbols is, however, limited, and in large works cannot, in general, be extended beyond general classifications of machinery or accounts. In some works the accounts are designated by numbers, whole numbers being used for the expense accounts, which usually are comparatively limited in number as compared with manufacturing accounts, for which some decimal notations based on the Dewey[2] decimal system is used.

73. The Sources of Cost Data. As explained in Art. 46 the production order, Fig. 6, is the most usual means of putting a job in production and in well-managed shops no labor or material expenditures are permitted without an order of some kind. Direct production is performed on orders issued as needed, each order bearing the assigned order number to which the work is to be charged, a new number being assigned to each piece of new work. The numbers or letters designating expense accounts are more permanent, however, and for these **standing orders** are issued that are valid until changed by the cost keeper.

As work of *any kind* is performed the workman keeps a record of his time and the order number to which it should be charged. There are two general ways of collecting this time. In the first method a traveling timekeeper visits each man daily and records

[1] For further discussion of this principle see Trans. A.S.M.E., Vol. 2, p. 366, Cost Keeping, by S. H. Bunnell, p. 123, and Applied Methods of Scientific Management, by F. A. Parkhurst, pp. 70 and 240.

[2] See Dewey Decimal Classification, from Eng. Dept., University of Illinois.

his time charges in a book, from which he transfers them to the cost record. The defect in this method is that the workman depends too much on his memory and where he is working on several different jobs daily his records, mental or written, are likely to be defective. A better and the more modern way is for the foreman to issue him a work card (Fig. 8) when he begins the job. This card may be arranged as in Fig. 8, so that he can check off elapsed time, or it may be stamped in a time clock at the beginning and end of each job. The card, as will be seen, contains somewhat full information regarding the work and the order number to which it is to be charged, and must be approved by the foreman. These cards are collected daily and charged against the several production and expense accounts. By making the cards of different colors they may be sorted and classified visually and hence rapidly. These work cards then form the basis of all *time* charges. If the work is being done on a premium or bonus system of pay, provision is made on the card for noting the premium or bonus earned.

The production order may be a blanket order authorizing the foreman of a department to proceed with a given job, and the foreman may have the authority to requisition the store keeper for the material required. This requisition when filled and priced may then be sent to the cost keeper. Expense material is most usually requisitioned in this manner, the requisition bearing the expense order number to which it is to be charged. Where careful planning of the work is attempted, however, the production order will list the material needed (See Fig. 6), a copy going directly to the storekeeper, who will deliver the material called for, evaluate the order, and return it to the cost department. The detail in which production orders may be issued will, obviously, depend on the detail desired in securing costs; and the extent to which material can be specified will depend on the amount of care and detail bestowed upon the drawings and specifications emanating from the engineering department.

Other sources of expense, such as gas bills, telephone and messenger service, clerical help on monthly salaries and sundry minor

expenses, will all appear as bills or pay vouchers and it is evident that there is little difficulty in securing fairly accurate allocation of labor, material and expense to the several order numbers to which they belong. The real problem of cost keeping is to distribute the summarized expense accounts fairly and equitably against the production or direct job numbers.

Methods of Distributing Factory Expense.

74. Characteristics of Expense. From the foregoing it will be evident that no serious difficulty is involved in finding the cost of the direct labor and material entering into the production of a given part. It is also evident that it is possible, without great complication, to classify the many items included in factory expense and to find the total amount of each item for any given period of time. It is not difficult, as will be seen, to charge off the *total* expense charges against production so that *total* costs are fairly accurate, but it is exceedingly difficult, except in simple cases, to apportion to each shop order the correct amount of each expense account so that it will bear its own share, and only its own share, of the burden. The reasons for this may be made a little clearer by considering a little more fully some of the characteristics of expense items. Direct material and direct labor are specific, tangible things that, as has been shown, can be accurately evaluated for any piece of work. But expense is variable in character and effect and does not attach itself in a tangible form to the work as it passes through the shop. The real problem of cost keeping is to apportion the expense items so that each job shall bear its own just share of burden. Unless this can be done with some degree of accuracy there is no way of computing the true selling price of the several lines of work even though the *total* costs may be sufficiently accurate to fix profitable prices.

The total expense of production is, in general, divisible into two classes, namely, *constant* and *variable*. As Mr. Going[1] has very clearly expressed it, constant expense includes all items

[1] For a very clear discussion of the elements of cost and cost keeping, see Principles of Industrial Engineering, by C. B. Going, p. 79.

necessary, so to speak, to the mere *existence* of the business, while variable expense includes all items connected with the *activities* of the business. Thus rents, insurance, taxes and depreciation of buildings remain practically uniform no matter what the volume of business in the shop may be; or if they change at all, it is occasionally and perhaps by large increments and then they remain stationary again for a long time. Moreover, many of them can never become zero no matter what the state of the business may be. Salaries of general officers and those that are not affected by a change in volume of business are also fairly fixed in character.

On the other hand expenses such as clerical help, unskilled labor, power, oil and similar operating supplies are affected quite sensitively by a change in the volume of business and go up and down with it *though not usually in direct proportion.* Thus it takes a certain minimum amount of power to turn the engine and shafting when no productive work is being accomplished. Any additional power required will evidently be some function of the volume of the work moving through the shop, the exact relation depending on the character of the work. In general then, the relation of power to volume may be expressed by the equation

$$P = C + f(V),$$

where P = power required, C = a constant and $f(V)$ = some function of the volume of work. Many other expense items are of this general character, the relations usually being far from simple. Evidently the amount of either constant or variable expense that a job must bear is dependent on the *volume* of work passing through the shop, this amount increasing as the volume decreases.

It follows, also, from the above that profits do not vary directly in proportion to the volume of business transacted. As the volume of business decreases the amount of expense that must be added to the flat cost of every article manufactured constantly increases because of the irreducible minimum expense. If the fixed expense is comparatively high the decrease in business need not be great before the increased expense on

each article swallows up all profit and any further decrease in business will result in a deficit.

A very disturbing element in allocating expenses is the manner in which some of them vary with *time*. Thus rents, insurance and taxes are direct functions of time and can be reasonably predicted. On the other hand the repairs on a cupola, involving the use of both expense material and labor, are necessary because of the wear and tear incident to the work of the previous week or month. Expense supplies may be purchased to-day because of favorable market conditions and their use may be extended over several weeks or months. Evidently it would not be accurate to charge off accumulated expenses of this kind against current production. Such expenses must be spread out and averaged over a reasonable period of time even though this period be somewhat arbitrarily fixed because of the difficulty of determining it accurately. In practical cost keeping averages of this kind must be employed for another reason. In most cases once a month is as often as it is convenient or possible to close the books and determine summarized costs. If now, every job could be started on the first of the month and finished on the last day of the month, it would be possible to assign to each job, as accurately as the method employed would allow, its own share of the indirect expense incurred during the month it was in production. But jobs are finished regardless of the day of the month and, in most instances, it is desirable to bill them when shipped, so as to collect the payment. Indirect expense must, in such cases, be charged off on the basis of the summarized costs of the previous month or other periods of time, the proportions for the current month usually not being available.

The proportion of certain expenses that various jobs should bear is dependent on the size or weight of the product. Thus, theoretically,[1] small parts should not be called upon to bear the cost of operation and maintenance of large cranes, large machine-

[1] It will be shown later that although, theoretically, small parts should not be taxed with expense incident to large tools, in practice this procedure is often necessary to prevent the cost of certain classes of work from being so excessively high as to make it unmarketable. Such a condition, however, is indicative of a weakness against competition in some line of product.

tools and large equipment generally. Clearly a large casting should bear more of the expense incurred in repairing the cupola than should a small one. The same difficulty arises with articles of different character. An article of one kind may give rise to indirect expenditures that are unnecessary in articles of another kind.

A similar complexity appears in considering the clerical work of the office and similar expenses. It may require more of such work to put a small complex machine through the shop than it would to put through a very large and more costly machine. And it can be seen that, in general, the cost of clerical work incident to a large and varied line of manufacturing is so complex as to render absolutely accurate allocation unprofitable even if it were possible. As in the former case it must be turned into the expense and distributed as intelligently as possible.

From the foregoing it is obvious that absolutely accurate distribution of expense is a very difficult if not impossible problem except in the very simplest cases, the complexity of the problem increasing with the complexity of the industry. In fact, different lines of work in the same factory may demand different methods of cost accounting, which is another reason for careful departmentization aside from those arising from productive processes. These features, no doubt, account to a considerable extent for the failure, often, of large expansions in a factory, or the consolidation of factories, to produce expected results. In the process of enlargement some vital characteristic of the accounting may be lost sight of. The effect of this lost item may not have been serious in the smaller groups, but may prove very disastrous to the enlarged organization. The necessity of an accurate system of cost accounting needs no defense. It is as much a high-grade tool as a high-grade lathe or planing machine; but, compared with the installing of a first-class machine tool, the problem of instituting even a fairly accurate cost-keeping system is, in a large works, almost infinitely more complex.

Now the manufacturer as a rule is much opposed (and often with good reason) to complex systems. What he wants, usually, is something simple and direct; and between the need of ac-

curacy on the one hand and the dread of complexity and added clerical help on the other, the system adopted is often a compromise. As a consequence there have grown up a number of approximate methods of solving this problem and the characteristics and limitations of the most important of these will be very briefly discussed. The fundamental idea on which these systems are based is to use some tangible feature of the job as a basis of comparison and by it to measure off the proper burden that the job should carry. It has already been noted that direct material and direct labor attach themselves to all jobs in a definite, tangible and measurable manner. The *time* element of direct labor is, therefore, also a tangible quantity; and if a machine is employed in the work the time of such machine service can be accurately determined. The following methods of distribution based upon the above factors are those in most common use, namely, by material, by percentage on wages, by percentage on prime cost (labor and material), by man-hours, and by machine rates. Another and more accurate method by so-called production factors has been advocated of late and will also be discussed briefly.

75. Distribution on Material as a Basis. In simple continuous processes where the output consists of one uniform product as in a rail mill, a salt works or a cement plant, it is obvious that if the expense incurred during a given period be evenly divided over the output for the same period the distribution will be correct. If the running conditions do not change materially, little error will be introduced if the expense incurred during the next preceding period of time be used as a basis. This is so, not because of the inherent accuracy of the method, but because *distribution* in a strict sense is not needed in such cases but only simple *division* of the indirect expense. In fact, in such simple cases the direct labor or the flat cost would be just as accurate as a basis. But if the product varies from time to time,[1] or

[1] Thus a sawmill will turn out more *board feet* of product when cutting large-sized product than when cutting smaller pieces, the indirect expense remaining practically the same. It is not customary, however, to take cognizance of this fact in distributing the expense.

if there is more than one line of product, these simple relations no longer exist and the introduction of material values into the computation of expense distribution is very likely to distort the results.

76. Distribution on Direct Labor as a Basis. The use of the direct labor as a basis of distribution is based on the supposition that the indirect expense chargeable to a job is proportional to the direct labor expended upon it. It is, perhaps, as generally used as any other method, probably because of its simplicity. If the total direct labor for, say, a month should be \$5000 and the indirect expense for the same time \$2500 then the indirect expense is 50 per cent of the direct labor and by this method the indirect expense would be distributed by adding 50 cents to every dollar expended for direct labor. If, for instance, a machine has been built during the period considered, the material for which amounted to \$200 and the direct labor to \$400 the factory cost would be

$$\$200 + \$400 + (\$400 \times .50) = \$800.$$

In practical operation the percentage used is, for reasons already explained (see Art. 74), not that of the current week or month but of the next preceding period or the average of several preceding periods.

If the work is of practically the same size and character and if the wage rate does not differ greatly the above method may, in many instances, be sufficiently accurate. But the method becomes more and more erroneous as the difference in size and character of parts become greater. Thus a job involving \$5.00 worth of labor by a man using a hammer and file is burdened by this method with as much expense as one involving a similar direct labor charge if done on a \$20,000 boring mill and requiring the service of a high-priced overhead crane. Yet the interest on investment necessary to perform the latter operation is very much greater than for the former both as to cost of tools, floor space, etc., to say nothing of the greater expense for heating, lighting and insuring that part of the shop that houses the boring mill. Again, as the volume of work fluctuates all lines

of work seldom vary equally, the difference being more marked when the difference in size is great and in such cases one line may have to bear interest and similar fixed expenses belonging to other lines to an undue amount.

One of the greatest defects of this method is its failure to take proper cognizance of the effect of elapsed time upon the costs. A job that takes a rapid man, earning 50 cents an hour, three hours to perform, is taxed the same amount as another job done under the same conditions by a cheaper man getting 30 cents an hour and consuming five hours for the work; and the shop cost of the article does not differentiate between the two. Now in manufacturing, especially, "time is money." Profits depend not on cost alone but on quantity of product (see Art. 74); and the work of the slow man involving a longer use of tools, floor space, light, etc., is, obviously, more costly than that of his more rapid neighbor.

It is evident that if all pieces of the same size were machined in the same shop, as is often the case in a very large works that has been departmentized along these lines, a varying and more equitable percentage could be applied to each class; and this is sometimes done in such cases. This principle has also been applied to shops doing mixed work by classifying the work and applying different percentages to the different classes, the larger parts carrying the heavier burden. Undoubtedly, if this can be done and if a graded percentage can be intelligently fixed it will give better results than the flat percentage, in all cases where there is variation in size and weight. The difficulties of doing this are, however, usually considerable.

77. Distribution on Prime Cost as Basis. There would seem to be little justification for this method of distribution and, as far as the writer is aware, it is little used. If the value of the material used in the product is very small compared to the labor put upon it the method approaches the use of direct labor as a basis; while, on the other hand, if the material values are very high compared to the direct labor the method approaches the use of direct material as a basis, and in either case is subject to the limitations and errors of these methods already discussed. In

mixed manufacturing, where one piece may have a high material value and low labor value and the next piece may have the relative values of these items reversed it is self evident that the distribution of expense by this method will be neither logical nor accurate.

78. Distribution on Man-Hours as a Basis. In distributing the expense on this basis it is assumed that the expense chargeable to a piece of work is proportional to the *number of man-hours* expended on it. It might seem that this system would give the same results as the percentage-on-wages method already discussed, and this would be so *if all men received the same rate of pay,* since then the labor cost would be proportional to the time consumed. Thus, suppose that, as in the case cited in discussing the percentage-on-wages system, the total direct labor for the month is $5000 and that it is made up of 10,000 man-hours at 50 cents per hour. Assume as before that the total indirect expense for the month is $2500. Let the material cost of the job considered be $200 as before and let the direct labor charge upon it be made up of 800 man-hours at the given rate of 50 cents. or a total as before of $400. Then the expense per man-hour chargeable against any job is $\frac{\$2500}{10{,}000} = 25$ cents per man-hour and the expense chargeable against the job under consideration is $.25 \times 800 = \$200$, the same as in the percentage-on-wages plan, and the factory cost is $\$200 + \$400 + \$200 = \$800$ as before.

But suppose that the wage rate is variable, as it most usually is, and that the labor cost of the above job consists of 1000 man-hours at 40 cents an hour or $400 as before. Now the expense chargeable against it is $\$1000 \times .25 = \$250$ and the total shop cost is $\$200 + \$400 + \$250 = \$850$. Again if the direct labor cost consists of 400 hours at $1 an hour the total shop cost will be $\$200 + \$400 + \$100 = \$700$; so that even though the labor cost may be the same the factory cost will be different if the time consumed varies.

This method has, therefore, the advantage over the percentage-on-labor plan of accenting the value of the time element

in costs, the factory cost in general increasing and decreasing with corresponding changes in the time consumed. Like the other system, however, it fails to take account of the difference in size and value of the equipment used, all jobs consuming the same amount of time being burdened equally, though in one case the workman may be using a hammer and chisel and in another a very costly machine tool. Like the percentage-on-wages system it will give satisfactory results only when the class of work and the machines employed are fairly uniform in size. Or, as Mr. Church [1] has expressed it, " where we have a simple set of facts to represent their representation is an equally simple matter."

79. Distribution by Machine Rate. The machine rate is a very old conception and, no doubt, has its origin in an instinctive effort to equalize in some degree the varying cost of production caused by the use of tools and processes of varying size and value. It was in use long before the days of refined accounting methods, so common to-day, and in its original form made no attempt to insure an accurate distribution of the total factory expense. It attempted, rather, simply to equalize such factors of expense as naturally attach themselves to machines and processes as, for instance, power, interest on investment, depreciation and repairs. The entire equipment was divided into classes by size or value, and a graded charge per hour was fixed for each class, a machine in this sense being any tool or process from a vise to the largest boring mill. Thus the charge per hour for a vise hand might be 50 cents, while the hourly rate for a large boring mill might be $5.

The theory on which the machine rate rests is, without doubt, much more accurate than that which underlies any of the methods previously discussed. Most of the items of expense do not connect themselves naturally with *wages* but do most naturally gather around *machines* and *processes*. Nor do they collect as a uniform layer over wages or time but gather in varying quantity around machines and processes. The rate of pay and the time consumed being equal, it costs a great deal more to do a

[1] Expense Burden, by A. H. Church, p. 34.

piece of work on a large mill than on a vise, since the larger tool costs more, originally, and such items as repairs, power, insurance, heat, light, housing, etc., are all greater in like proportion. It was most natural, therefore, that this method should be extended to the problem of distributing the *total* shop expense, for it is to be especially noted that this method of distribution applies the burden at the time and place that the work is performed; and if the machine rate is correct for the existing conditions of production the result must be much more accurate than that of any of the averaging methods discussed, for all cases where the machines and processes vary in size and value.

In determining rates for the purpose of distributing the total expense, all items of expense are apportioned so that each machine or process bears its own just share of the expense as nearly as possible. The total of such allocated expenses assigned to any machine[1] is then divided by the *estimated* number of hours the machine may be expected to be in operation during the period considered, this estimate being checked, if possible, by records of past performances. This gives the hourly rate of the machine and every job that passes through it is charged accordingly. Obviously, if this allocation be correct, and if each job be properly assessed as it passes through the several processes, and also *if all machines are in operation the exact time estimated*, all the indirect expense will be distributed in proportion to the use that has been made of the various machines and processes.

The theory of the method, as before stated, seems very accurate; but the difficulty begins when any departure is made from the estimated time that machines are in operation. If a machine fails to run up to this normal time an undercharge is made; if it is in operation more than the normal time an overcharge is made. This last may not be so serious, but when the volume of the work is even slightly decreased and a few ma-

[1] A machine in this sense would be any actual machine, or a vise or in fact any *place* where a workman is employed, if full distribution of expense is to be attempted in this manner.

chines[1] become idle, a large undercharge is incurred. This undistributed expense due to machines being idle does not appear in the cost of production and is lost sight of until it appears in the totals of the profit and loss account. Any approach to accuracy depends, therefore, on every machine and process being in operation the exact amount of time used in estimating the machine rate. Such conditions seldom prevail in any shop.

There is one objection that is sometimes raised against the machine rate and that is the large amount of expense that, under this method, is charged against a job that is done in a machine larger than is actually required for the process, because of smaller machines being oversupplied with work. This makes the cost of this so-called "penalized" job appear excessive; and if taken as a guide for future work is misleading. On the other hand the fact that it is high is an instant indication that the most economical process is not being employed and points at once to a weakness in the manufacturing equipment. It is better to know that the cost is high, and to be able to find the reason, and make such allowance as may be necessary, than it is to have an undiscovered weakness in the manufacturing processes.

80. The Machine Rate and Supplementary Rate. An effort[2] has been made to compensate for the error introduced into the machine rate when machines do not run up to their estimated normal time by the introduction of a so-called **supplementary rate.** The operation of this auxiliary rate is as follows: Such expenses as can be apportioned to machines and processes are so allocated and charged off, as before, by a machine rate. A record is kept of all expense actually charged off in this manner and at the end of the month the total of such distributed expenses is subtracted from the total expense that should have been distributed. The difference is the undistributed expense and this may be distributed as an hourly charge over the several jobs or by proportioning it over the jobs as a percentage on the

[1] The error from this source is magnified by the fact that in dull times the large machines whose rates are highest, and hence discharge more expense per hour, are usually the first to be out of work, and the last to be in operation as times improve.

[2] See The Distribution of Expense Burden, by A. H. Church, p. 46.

expense already allocated to them. If all the machines have operated up to a normal time the undistributed balance at the end of the month will consist only of the general shop expenses that cannot be distributed by the machine rate and this, usually, is a comparatively small amount. The undistributed balance then becomes a gauge of the time efficiency of the shop and a valuable index of how closely it is working up to its capacity.

81. Distribution by Production Centers. The inherent advantages of the machine rate has led Mr. A. Hamilton Church [1] to propose a more refined application of its underlying theory. Suppose the factory under consideration to consist of a large number of small units separated physically from each other but supplied from central sources with such general requirements as heat, light and power in such a way that all such requirements could be accurately charged up against each unit. Suppose, further, that these units are of different sizes and contained processes and machines of varying character and size. Let it be further supposed that the owner of the factory operated some of these units personally and rented others to employees. Obviously, he could not, and would not, charge off his general shop expenses by any system of *averaging*, but would be compelled to consider each unit separately, keeping a separate record of each and every " service " or " production factor " and of the exact amount supplied to every production unit or " production center " as these units may be called. Thus it would be possible to apportion to each unit the expense incurred because of the land and building it occupied, the insurance and depreciation of the building and the cost of heating, lighting and supplying power. Other items of general service such as transportation, stores, telephone service, supervision, etc., might be more difficult to apportion accurately; but a fair approximation could be made, in fact, would have to be made, the owner keeping a *separate account* of each and every service rendered.

Obviously, also, if a tenant renting one of these units, wished to compare his costs of production with a neighbor, whose unit

[1] See Distribution of Expense Burden, p. 46, also Production Factors, by the same author.

was larger or smaller, he could reduce his several expenses to such a form as would make comparison easy. Thus his rent could be expressed as so many dollars per square foot of ground occupied, and his light and heat in similar terms; and if he had more than one machine in his unit these rates could be used in determining the relative cost of production between machines. Moreover, knowing just what these several expenses were for a given period of time he could add thereto those expenses that were directly connected with his tool or process, such as interest, depreciation, oil, etc. Then by estimating, or otherwise determining the number of hours that his machine or process would be in operation during that time, he could calculate a machine rate, as explained in the foregoing paragraph, that would discharge all this expense as the work passed through his machine or process. His floating expenses that could not be so reduced would be discharged as a supplementary rate which would also care for discrepancies in his estimates of his machine hours.

Now Mr. Church contends, and with good reason, that these conditions do not change simply because the walls are taken away from the small units and a large building, housing them all, is erected instead. His argument is that the manufacturer should still keep these several expenses as separate accounts,[1] and still considering each machine[2] or process as a "production center," assess it for each service according to an accurately determined or "scientific" rate. The production factors that can be so treated and the methods of reducing them to chargeable terms he lists as follows:

Land-building factor, measured by..	floor area.
Power factor, measured by.........	horse-power used.
Lighting factor, measured by.......	floor area.
Heating factor, measured by.......	floor area.

[1] Mr. Church's system of control accounts by which he proposes to keep track of the several production factors is most interesting but is beyond the scope of this book. See Production Factors, by A. H. Church, p. 138.

[2] Machine and process here, as before, meaning any piece of apparatus or, in the case of handworkers, a stationary place to work.

Organization factor, measured by...	simple division.
Supervision factor, measured by....	special determinations.
Stores-transportation factor, measured by........................	special determinations.

In addition each machine or production center would be charged with the expenses arising out of the character of the machine itself as, for instance, interest on first cost, insurance on the tool itself, repairs, supplies, and wear and tear on cutting tools and special fixtures. All of these, as before noted, can be reduced to a machine hour rate and can be charged off as the work moves through the machines or process, the supplementary rate caring for the comparatively small amount of expense that cannot be allocated in this manner, and also for the discrepancies due to variations in the machine time from the normal estimate.

The philosophy of this method is sound and where it can be realized it will no doubt give very accurate results. There are, however, several serious difficulties in operating it. The preliminary study and preparation necessary to install accurately such a system would be great even in factories of moderate size, and in very large works would be exceedingly difficult if not impossible. Some of the production factors, such as heat, light and insurance on buildings can, perhaps, be allocated in almost any factory with an approach to accuracy. In the case of power, especially where large amounts are used in a variable way for testing and where complex systems of shafting and belting, air and hydraulic distribution serve many and varied machines, accurate allocation is impossible; or at least would require such elaborate system as to make the net gain realized doubtful. In comparing the accuracy of distribution of this system with the averaging methods formerly discussed it must be kept in mind that some of the production factors themselves are based on averages. Buildings are not heated or lighted at the same rate all the year around, repairs to buildings and machinery are not proportional to elapsed time, and expense material may be bought to-day that may not be used for several weeks or even months. Moreover, as already noted, it is not always possible, or at least desirable, to wait until the end of the month to bill

goods that are shipped early in the month. If bills are to be sent out promptly with the shipment the production factors and supplementary rate must be based on records of previous performances; in fact, in a large works, where many small shipments are made daily, this supplementary rate would have to be determined by previous performance, for the work of going back over the months shipments and making a redistribution would involve a very great periodic increase in clerical labor. Any claims to refined accuracy in this, or in fact in any other method of distributing expense, must, therefore, be taken with caution. Nevertheless, the machine rate offers a more logical method of solving this problem than any other. It will probably be some time before an extended use of the refined method outlined by Mr. Church is realized; but a machine rate for classes or groups of machines can be readily applied and is in fact in common use; and there is no doubt but that this method in connection with the supplementary rate offers the best solution of the problem for most plants with diversified equipment.

82. Distribution of General Expense. The general expense[1] (see Art. 64) consists, strictly speaking, of two parts, the **administrative expense** of operating the factory and the **selling expense.** This expense cannot, usually, be charged against specific production orders, the connection between selling and manufacturing being, most usually, very vague. It is often possible, however, to apportion this general expense between the several *lines* of product with some degree of fairness, especially when the works are so large that the administrative and sales department are, of a necessity, departmentized. These expenses are most usually distributed over the factory cost as a percentage. Thus, suppose that the total output of the factory for a given month is $200,000 and that the general expense for the same period is $50,000. Then the percentage by which the factory cost of each article must be increased in order to absorb the general expense is $\frac{50{,}000}{200{,}000} = 25$ per cent. Similar reason-

[1] The duties of some officials may be divided between these two divisions of the work and their salaries would then be so distributed.

ing applies if the general expenses are apportioned to departments.

It may be desirable in some works to keep the sales expenses entirely separate from the general administrative expenses, in which case the selling expense is sometimes distributed as a percentage over the gross cost, *i.e.*, the factory cost plus administrative expense.

It should be carefully noted, also, that the ratio of burden to direct labor, or burden to prime cost, or the ratio of indirect labor to direct labor is not necessarily an index of the efficiency of the factory. It is true, of course, that all indirect expenses should be carefully guarded for they tend naturally to increase unnecessarily unless carefully watched. As the quantity to be produced increases, however, it becomes increasingly easy to separate mental and manual processes and to apply transfer of skill; and the application of these principles usually increases the ratio of the indirect labor charge to the direct labor charge. To illustrate, suppose there was just enough of some product to keep five men busy on standard lathes, but not enough to warrant the purchase of an automatic lathe for the work. Then the direct labor charge would be the wages of the men employed, and if the work was of small size involving no high-priced designer the indirect labor charge would be small. If now, the quantity is increased so as to warrant the purchase of a full automatic machine for the work, and the work is, consequently, transferred from a general machine floor to an automatic machine floor, the labor on the parts will probably be of the indirect class entirely, as the duties of the men in the automatic room are so varied as to make accurate allocation impossible. It is clear, however, that in this case the total cost of the parts concerned will be greatly reduced though the indirect charges will be greatly increased, and the direct labor charges reduced to zero. As a matter of fact it may be that a high direct labor charge and a low indirect labor charge may be an index of bad management rather than an index of cheap production.

83. Summary. From the foregoing brief outline of the methods of distributing expense it will be seen that the problem is usually a difficult one and not, in general, capable of exact so-

lution. There are, however, certain fundamental principles that should not be lost sight of, no matter what the system adopted may be. The method adopted should be as simple as the problem will admit. Thus, it would be folly to install an elaborate machine-rate method in a continuous process plant manufacturing a single commodity, where a percentage-on-material method is amply accurate. Again, in cases where a few lines of goods are made on small machines of low value the percentage-on-wages or the hourly burden method may be fully adequate. Where the lines of production vary widely in size and character these simple systems are not sufficiently accurate, and the careful manager will go as far as he can in the direction of the machine rate. Almost any shop can be departmentized and the indirect expense distributed with a fair degree of accuracy between departments. How far beyond this the manager can go economically will depend on conditions. In any case he should see to it that *all* costs are distributed. On the other hand if he employs a professional organizer to assist him he will do well to have a clear understanding in the beginning of just what costs he desires to obtain and not install a lot of useless detail, the expense of which more than offsets the gain. There is a great difference between *principles* and the *detail* to which they may be carried. The expert organizer should be a master of the principles involved and be able to install a satisfactory system; the manager on the other hand should be able to guide him in the matter of detail. The two working together should be able to install a system that will obtain the desired results at minimum expense.

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CHAPTER X.

THE DEPRECIATION OF WASTING ASSETS.

84. Nature of Depreciation. The assets of any industrial undertaking are usually divisible into two classes, namely, **fixed assets** and **floating assets.** Under fixed assets are included land, buildings and machinery necessary for the work; while under floating assets are included the purchased materials operated on, with such supplies, cash, bills receivable, etc., as are a necessary part of the business. The total amount of the assets may be fairly constant, but the distribution of this total among the several classes of assets may vary constantly with variations in the business. Now, manifestly, some of these forms of assets are stable and do not necessarily change in value, or if they change it is by slow degrees. Thus the land may appreciate slowly, or the purchasing power of the cash may slowly increase or decrease depending on many circumstances.

Other forms of invested capital, however, constantly tend to decrease in value whether the business is operated or not. Thus, the buildings waste away because of the action of the elements and also by reason of wear and tear incident to the industry. Machinery and furniture of all kinds tend to wear out and must be renewed. Purchased material, that has been fabricated into saleable product, may depreciate greatly if held in store too long, either from the action of the elements or from being superseded by other types of product. Even unworked material may depreciate to scrap value by reason of changes in design or manufacturing processes, especially if it is of special character and not a standard market commodity. These two last forms of depreciation are particularly likely to occur in new industries where the development is rapid.

Invested capital may be lost in one of two ways; and for convenience these may be distinguished as **losses on capital account** and **losses on revenue account.** If an uninsured ship is lost at

sea or an uninsured building is burned, the loss is clearly a loss of capital that has nothing to do with depreciation. To replace such losses the owner must furnish new capital whether he takes it from his surplus savings or borrows it elsewhere; but clearly no allowance for wasting depreciation that he makes on his remaining property can be properly said to replace the loss.

Losses on revenue account are those incurred as the result of trading. Thus, if a company begins business with a total capital of $200,000 and at the end of the year has its original equipment (having suffered no loss on capital account) but finds that after proper allowance is made for wasting losses it possesses only $150,000, it has suffered a loss of $50,000 on revenue account. Depreciation is one of the elements that enter into and intimately affect loss or gain on revenue account and the above distinction is important.

Investments that unavoidably deteriorate through the action of the elements or through wear and tear incident to the industry are termed **wasting assets.** Evidently they will vary in character with the character of the business, and a careful investigation should be made of every undertaking to determine just what wasting assets it includes in order that proper allowance can be made for them by setting aside money from revenue sufficient to keep the capital account intact.

A careful distinction must sometimes be made between the several ways in which assets may lessen in value. In the case of the appraisal of a public utility enterprise as, for instance, a street car system or a telephone system, where toll rates are to be fixed upon the basis of the valuation, the following forms of lessening value may be, and often are, recognized:

(1) **Wear and tear or maintenance.**

(2) **Physical decay or decrepitude.**

(3) **Deferred maintenance or neglect.**

(4) **Inadequacy.**

(5) **Obsolescence.**

85. Wear and Tear or Maintenance. From the moment a building is erected or a machine is put into service deterioration begins because of the action of the elements or the use of the

building or machine. Thus, the bearings of all machines wear more or less, the paint on the building begins at once to wear off, the commutator of a dynamo must be replaced or a new tire must be put upon a wagon wheel. Deterioration of this kind, that can be compensated for by proper repairs and renewals, is usually known as **wear and tear.** Depreciation of this sort varies greatly in its effect with different classes of apparatus. In some cases the effect is very great in the beginning of the life of the asset, slowing up as time goes on; while in other cases the reverse may take place, the deterioration because of wear and tear becoming greater in effect as the end of the working life of the asset approaches. In this class of depreciation may also be included the results of accidents or sudden damage from unforeseen causes, and when these are abnormally great they should be charged off over a considerable length of time so as not to augment the current operating expenses excessively. (See Art. 74.) It is customary, in most plants, to charge the expense of compensating for wear and tear, which is the most apparent form of depreciation, to operating expense, thus making it a direct charge against production.

86. Physical Decay or Decrepitude. Even when a machine is kept in first-class repair, or when a building is kept properly painted and repaired there is a general deterioration that goes on continually that cannot be thus compensated for, and in time, the structure or machine will reach such a state that nothing short of complete renewal will suffice. In many cases this gradual lessening of value by age will be the same or even greater whether the asset is used or not. Buildings, boilers, insulated wire and similar assets will waste away by the action of the elements as rapidly when standing idle as when in operation, and it is common experience that such properties, in time, reach a state of decay where repairs are no longer economical. Such deterioration is called **decrepitude** or **physical decay.** A horse is a most excellent example of this form of depreciation. His shoes can be kept repaired but the gradual breaking down of his physical powers cannot be stayed by any manner of repairs or renewals. He must be *replaced.*

87. Deferred Maintenance. It is clear that even though repairs and maintenance are properly provided all physical assets will, in course of time, depreciate below their original value even though their productive powers are as high as in the beginning. In fact, after a few years it is probable that, even with the best of maintenance, a plant of any kind cannot be put in a condition that will exceed 85 per cent of its original value. If, however, the proper repairs and maintenance are not provided the value of the asset will fall below the value it should have, if properly maintained, and the amount it may fall is known as **deferred maintenance** or **neglect.** Deferred maintenance is a measure of the amount that must be expended to restore the asset to normal working condition and is, therefore, a measure of the efficiency of the management or its financial ability. This form of depreciation is obviously important in appraisal work where interests other than those of the management are concerned.

88. Inadequacy. Even though the asset may be kept in full repair it may become uneconomical or even useless because of increased demands of the service, though it may still be fully adequate to do the work for which it was installed. Thus an engine may become too small for the work required, or street cars may become too small to be economical for the increased service demanded. If heavier cars are installed they will make heavier rails necessary, though the old rails may not be worn. An overhead crane may be in good repair and of modern type, but may be found inadequate to meet the requirements due to growth. This kind of decreased value is called **inadequacy,** or **supersession.** It clearly has no connection with age or time of service or the physical condition of the asset so far as wear and tear is concerned.

89. Obsolescence. Assets may become of lessened value because of the introduction of new types of apparatus or new inventions or processes. This is particularly true in any industry or business that is developing rapidly. Thus, in the development of the textile industries of New England a heavy burden was imposed upon manufacturers because of the rapid

development of new machines, that gave a great advantage to other men seeking an opening in the field and compelled the older owners to scrap their machinery long before wear and tear had become noticeable. The same effects were very common in the electrical field during the early periods of development and still prevail, in fact, in many lines of that industry. The history of street car traction is a remarkable instance of the effect of obsolescence. The change from horse cars to cable cars, from cable cars to electrical propulsion and the very rapid growth of this last system has been marked by the abandonment of much apparatus long before wear or decrepitude would have compelled such a step. Such depreciation is called **obsolescence.** It is very similar to inadequacy in its effect but proceeds from different causes. Machinery or other assets thrown out of use by reason of inadequacy may still have a high market value; but machinery abandoned because of obsolescence is, in most cases, valueless except for scrap since, here, the economic use of the asset is destroyed regardless of its size. Inadequate machinery may be of good service in some other place or under other conditions.

As before noted any or all of these forms of lessening value may be important in appraising properties where conflicting interests are concerned, as in the valuation of railways or other quasi-public enterprises, or in differences of opinion between stockholders and bondholders. In the case of simple depreciation of factories, where the owner is desirous only of knowing the total of such losses, these several classes of wasting losses may be, and usually are, grouped under two heads, namely, **depreciation,** which includes the effects of wear and tear, decrepitude and deferred maintenance, and **obsolescence,** which includes inadequacy also. The effect of the first group included in depreciation can, obviously, be estimated by observation, or if data are available some systematic method of compensating for these effects can be adopted. Obsolescence, however, cannot always be adjudged visually, but it is possible often to make estimates on the probable life of the asset at the end of which it will be obsolete. A discussion of the methods

of providing for these losses will be given in a succeeding article.

90. Relation of Depreciation to Capital. Many undertakings must face what may be termed **obligations.** Thus, money may have been borrowed, payable at a definite future time. Machinery may be installed in a rented factory under the agreement that it becomes the property of the landlord after a given fixed time; or valuable patents may have been acquired whose value is comparatively short-lived. To meet these obligations an annual sum may be set aside from revenue, thus forming a **sinking fund** that, under compound interest, will accrue to the desired amount at the expiration of the allotted time.

The importance that should be attached to distinguishing between sums of money set aside out of revenue for specific purposes will, clearly, depend on the nature of the business and the manner in which it is owned and operated. Sometimes neither reserve fund nor sinking fund is necessary, but allowance must nearly always be made for depreciation and obsolescence and care should be taken, if only one fund is set aside, that it shall be sufficient to cover not only the specific purpose for which it may be intended but for depreciation and obsolescence as well, if these are not cared for in some other manner. In general, the larger the undertaking the more important is it that these accounts be segregated, while in small plants provision for wear and tear, obsolescence and other contingencies is often made under the one head of allowance for depreciation, thus greatly broadening the significance of the term. In large undertakings, on the other hand, the conflicting interests of stockholders and bondholders may make it undesirable to establish large reserves for unforseen contingencies, as it is difficult, often, to convince stockholders of the necessity of such funds which they would prefer to see distributed in dividends. For this reason reserves are often hidden under the general name of depreciation though the practice can scarcely be commended.

The capital investment of practically all industrial enterprises includes some wasting assets; and it is evident that they should be carefully considered. These wasting losses are in

reality a charge against production and the fact that they do not make themselves known through the payroll, the material requisitions, or bills payable renders them all the more elusive and dangerous. Suppose, for instance, that an enterprise is started with $100,000 total assets, divided into $60,000 fixed assets, $25,000 worth of material in process, and $15,000 cash. Suppose that at the end of ten years the owner has disbursed $20,000 in profits, but on taking a careful inventory he finds his fixed assets to be worth only $30,000, his material in process to be worth $20,000 and his cash to be $10,000 or a total of $60,000. Clearly, his apparent profit of $20,000 has been made at the cost of a loss of $40,000 from his capital;[1] in fact, his *apparent* profits were taken *out of capital.* The following basic rule may, therefore, be stated: **no profits should be declared until all losses to capital through the revenue account have been replaced from revenue.**

This principle is even more clear in considering undertakings that are limited in extent or time. Thus, in the case of a man who acquires a piece of coal land and sinks a shaft for the purpose of taking out the coal, his investment is represented by the purchase price of the land and the cost of his shaft and equipment, with such cash, etc., as may be necessary for operation. When the coal has been removed the land and machinery may be valueless, or nearly so, depreciating yearly as he removes the coal. Clearly, he must sell the coal at a price that will return him his original investment plus the cost of operating, plus such a profit as he may expect to make on his investment. Goodwill, patent rights and similar investments, that depreciate with time, are of the same character and must, in general, be returned to capital out of revenue before they expire; and profits cannot be said to have been made till all such wastes have been returned to capital.

The relation that depreciation bears to assets and profits is not always easy to see. Floating assets such as cash, bills receivable and materials in process can be readily evaluated and, usually, the books of any concern give minute details of these

[1] It is assumed that he has no liabilities in either case.

accounts. But the actual changes that have taken place in the value of buildings and equipment are seldom accurately known, first because it is (as will be seen) difficult to evaluate these changes, and second because, as noted, these changes in value do not *force* themselves upon the attention of the accountant as do other items of manufacturing expense. Nevertheless, this fundamental relation is clear, that it is not safe to declare profits[1] of any kind till assured that all wastes of the assets have been replaced. It may be noted here that the care that will be exercised in enforcing this important principle often depends on the character of the parties owning the industry. To the individual owner, or to simple partners, the above reasoning will appear sound and will usually be followed as far as possible or desirable. When, however, the business is owned by a corporation of stockholders, and has issued bonds that are held by so-called bondholders, there is a diversity of interest that may affect the rate of depreciation greatly. The bondholder does not run the business and has no vote in its management but simply loans money to the corporation, taking a bond as security and receiving interest on his loan, usually at a fixed rate. Evidently his bond is secured only so long as the assets that it represents remain unimpaired and hence he will most naturally want to see depreciation of all wasting assets fully restored, even though no dividends are paid beyond the interest on the bonds, which have first call on any payments. The shareholders or apparent owners of the industry, however, are interested more in the *profits* of the business. They may be, and often are, a continually changing body and would not, in general, be concerned if profits were paid out of capital, because of inadequate allowance for depreciation. Unless, therefore, the officers of such a corporation do make proper allowance for depreciation before declaring profits they are not dealing fairly with the bondholders who are their creditors. It is to

[1] The term profit here is used in a general sense meaning any surplus in the trading account after wasting capital losses have been replaced. Strictly speaking, however, profit is any surplus left after *interest* on capital investment has been allowed. (See article 66.)

be noted that excess allowance for depreciation usually does no injury to either bondholders or stockholders since it serves only to make the stockholders' security more secure and leaves a surplus in the hands of the stockholders for administration. However, as will be seen later, there are limitations also to this procedure.

This divergency of interest often occurs where a building or factory is rented by the manufacturer. The owner is interested in obtaining his fixed rental, and also in seeing that the plant is kept in thorough repair. The tenant is interested in upkeep only so far as it affects his profits. A written agreement is essential in such cases as this divergent point of view is often the cause of legal action.

91. Relation between Depreciation and Repairs and Renewals. Expenditures made for repairs and maintenance tend, naturally, to offset depreciation due to wear and tear, but it is only in certain cases that they may be considered as completely balancing depreciation losses. Where the plant consists of a large number of units that wear out so quickly as to need frequent renewals the very fact that it is in full working order is sufficient proof that depreciation is fairly compensated for. Again, in very large and permanent undertakings, such as railroads, where a large amount of repairs, renewals and additions are constantly under way, it is often assumed that depreciation is thus fully compensated for. Evidently there should be an obvious increase in the plant yearly to insure that such is the case, or otherwise there is danger that a gradual lessening of value may really be taking place. For, in general, it cannot be assumed that the ordinary running repairs and renewals compensate for depreciation. A machine or building may be kept in prime repair and worn parts may be replaced from time to time; but in spite of the best of care, there is, and must be, a general wearing out of the asset till nothing short of complete renewal can be considered.

It is, of course, true that extensive repairs may, in some cases, be considered as offsetting a certain amount of depreciation, but such allowances should be made with care. In a similar manner some renewals may be considered as additions to capital.

Thus, suppose a boring mill that was originally worth $10,000 is sold to a second-hand dealer for $2000 and a new mill bought for $20,000, being paid for by the $2000 from the sale of the old mill and $18,000 taken from earnings. Clearly, it would be fair to make an addition to the capital account of $10,000 provided, of course, that the earning power of the new mill was greater than the old one in proportion to the difference in price. By similar reasoning it can be seen that renewals may just balance depreciation; but care should be taken that such renewals are not considered as additions to capital unless they really increase the earning capacity of the plant. In fact, new additions to the plant should not be considered as additions to capital unless it is clear that they increase the earning power, and also that the investment in the additions is not compensated for by the deterioration of the older part of the plant, for which no provision has been made in the form of a reserve fund.

92. Methods of Depreciation. From the foregoing it will be clear that the object of computing depreciation is to make sure that all deterioration of the wasting assets is fully restored before any profits are declared. The value of the continuous and unavoidable wastes in the plant are taken from revenue and transferred to the floating assets in the form of cash or some other floating asset and if the computation for depreciation is correctly made the total assets will remain constant[1] in value. The funds so set aside from revenue may be employed in the business in other ways, or they may be placed at interest, if not needed in the business, thus forming a reserve fund that may be drawn upon for renewals or repairs of such a character as may be justifiable.

While the necessity of making allowance for depreciation is generally admitted, there is little unanimity of opinion as to the methods to be pursued in making such an allowance. This is naturally so since industrial enterprises differ widely, and besides, what may be *desirable* may not always bé *expedient*. There is

[1] Of course additions may be made to capital from some outside source or by adding to it from the profits, but this does not affect the above principle so far as the original capital is concerned.

often, however, too great a lack of knowledge of the fundamental principles involved and systematic methods of providing for depreciation are the exception and not the rule. Some managers are content to consider the amount spent from revenue for additions, repairs and renewals as sufficient to compensate for depreciation. The limitations of this procedure have already been discussed. Others are content to take the difference between an estimated percentage of depreciation and the cost of repairs and renewals as a measure of the depreciation; but such rules are of a necessity rough approximations. Probably the most common way of ascertaining depreciation is to take an inventory of all assets, visual examination being made of each and every tool and appliance, and the apparent value noted. The sum of the values thus found is the apparent valuation of the plant, and by comparison with former records the depreciation may be determined. This would seem to be the most practical and satisfactory method, particularly where the books of the concern are closed at stated periods, say annually, and a balance made of all accounts. There are some disadvantages, however, in this method, because of the large amount of time, trouble and expense involved, especially if the plant is a large one; and in very busy seasons it may be very undesirable to take such an inventory, particularly if it involves a suspension of work. Moreover, a visual examination of a machine may, or may not, give a correct estimate of its real value. A machine several years old may appear to be in first-class order, yet, nevertheless, its working life shortens yearly and due provision should be made against the time when it must be replaced or is rendered obsolete. It requires rare judgment and great experience to estimate accurately plant values visually. A periodical survey of the whole plant is, however, a very valuable and necessary proceeding, as it may serve as a check upon any systematic method of computing depreciation.

Some care must be exercised in placing a valuation on any industrial property since the purpose of such a valuation is to show what it is worth as an asset. Equipment may have several values depending on how it is viewed. There is a great

difference in the value of a plant as a going concern to its owners, and the value of the same plant to a purchaser if it is disposed of at forced sale to satisfy obligations. Every tool depreciates considerably in market value the very first time it is used, though its intrinsic worth may not change. It would not seem fair, however, to evaluate such property at the lowest price, namely, forced sale value, so long as the concern is a going one, unless the business is exceedingly profitable and the owners can afford to carry the value of the plant at a sum that is on the extreme side of safety.

In appraising [1] public utilities several kinds of value may be, and often are, recognized. Thus the **service value** or the value of the asset as measured by its present effectiveness for the purpose for which it was installed, may be important in such cases. This may be high, though the property may be considerably depreciated, theoretically. Another basis for valuation of utilities and one that has been approved by the courts of some states is the **cost of reproduction,** of the asset considered, with new apparatus of the same kind and efficiency, at the current market prices.

If from the original cost, if it be known, or from the estimated cost of reproduction new, there be taken the total depreciation, the so-called **present value** is obtained. This is the value that is most used in evaluating factory assets for inventory purposes and which will be discussed more fully later.

In making an evaluation of any asset, care should be used to separate recoverable values from those that are irrecoverable. The *total* cost of a machine is its purchase price plus freight, cartage and cost of installation, including the foundation. A machine does not change in value if moved from one position in the shop to another, but the outlay incident to erecting it in the original location vanishes the moment it is moved, and cannot be regarded as recoverable in any sense. In fact, it may be an expensive matter to remove or remodel the old foundation to make the site available for other operations. Such items of expenditure, therefore, should not be included in the inventory

[1] See Valuation of Public Utility Properties, by Henry Floy, p. 13.

value of the machine, but should be charged to a preliminary expense account and written off independently and as quickly as possible by depreciation methods.

In addition to the physical assets that are **tangible,** that is, assets that are visible, there are usually other items that are **intangible** and invisible, that are, nevertheless, assets in a true sense. In this class would be listed all development expense such as engineers' surveys, legal expenses of organization, cost of franchises or permits, salaries and all other expenses incident to, and chargeable against, construction, and similar expenditures that are a part of the cost of the plant but do not show as visible or tangible property in the inventory. Such expenses are a true part of the cost of the plant but are not easy to recover if the plant is sold. Best practice carries all such expenses in a separate **development account** and makes provision to depreciate it out of existence by means of sinking fund methods to be described later. Intangible assets, such as cost of franchises, patents and short-lived assets, in general, that are not a part of construction expense should also be carefully segregated and provision made for writing them off as quickly as possible.

From the foregoing it will be clear that there is a difference in the valuation that should be placed upon an asset depending on the purpose for which the valuation is made. Setting aside the modifying influences that arise in making such valuations of property for the purpose of fixing rates for public service and similar cases, it is clear that for the usual purposes of inventory this value will lie between the original or cost value and the ultimate or scrap value of the machine. The rate at which the value of the asset will fall from the original value to scrap value will depend on several factors and may vary with changing circumstances. It is customary in most well-operated plants to establish *average* rates of depreciation, these rates varying with the character of the plant, so that each asset or class of assets can be depreciated yearly without much trouble, and to check the results by partial or complete visual examination at longer periods. These depreciation rates may be adjusted from time to time as variations in the business or extensive repairs and

renewals make it necessary or desirable. The three principal factors involved in establishing such rates are:

(1) The first cost of the asset, whether building or machine.

(2) The estimated productive life of the asset.

(3) The residual or scrap value of the building or machine.

The two factors that tend most to modify any systematic scheme of depreciation are:

(1) Extensive repairs or renewals.

(2) Obsolescence[1] of the asset due to change in productive methods or the introduction of new machines or processes.

To illustrate, suppose that a milling machine is purchased for \$3000, the estimated producing life of which is 10 years. Suppose, further, that it is estimated that the residual or scrap value of the machine is placed at \$600. The total depreciation, excluding modifying circumstances, is \$3000 − \$600 = \$2400; and this must be distributed over the life time of the machine, or 10 years, by some systematic method. Suppose that by the systematic method adopted the book value of the machine has been reduced to \$1000 at the end of four years, and at that time the machine is thoroughly repaired and put into first-class condition, these repairs costing \$1000. If the design and producing power of the machine still compare favorably with new tools of the same kind it is clear that because of these thorough repairs the book value of \$1000 can be increased to, say, \$1500 and the rate of depreciation readjusted. On the other hand, the machine may at the end, say, of the third year be found in first-class condition, but be almost valueless because of changes in manufacturing processes or because of new inventions. Special tools are much more likely to be thus affected than are those of standard design and type.

The probable life of any machine, or building, varies with the industry and class and character of the equipment. Care and character of service, and the hours of actual use also contribute to this variation. For this reason, while it is necessary to assume a working life in arranging a system of depreciation,

[1] There may be cases where changes in processes may cause machines to *appreciate* in value, but such cases are rare. Land often appreciates in value.

the inventory values as given by any system should be checked occasionally by actual examination, particularly where obsolescence is possible.

The ultimate selling value of any machine will, obviously, depend on many factors, and must, in general, be estimated. In the extreme case, the ultimate value will be the value of the machine as scrap and this, again, would depend on the materials of which it is made and the difficulty of reworking them. Thus small, complicated apparatus, composed of various materials as steel, cast iron and brass, are often costly to dismember; while very large and thick castings are expensive to break up.

The rate at which the asset shall be depreciated from the original cost to scrap value over the assumed life requires special consideration. The assumed rate will lie, in general, between two extremes. If the asset has been kept in first-class repair and has not suffered from obsolescence, its value for the purpose for which it was installed may decrease very slowly for a long time, actual depreciation becoming very rapid only near the end of its productive life. To carry any wasting asset at a high valuation for a long period of time is, however, courting disaster, if there is any danger whatever of any readjustment of the business that would involve an appraisal of the property, particularly if such readjustment resulted in a forced sale; and most prudent managers carry the value of their plant on their books at a constantly decreasing value to guard against such a contingency.

The market or commercial value of a machine, on the other hand, falls very rapidly during the first part of its life though its producing power, and value as a going asset may not decrease. As before noted it would be obviously unfair to depreciate suddenly all new assets during the first years of their life and in the case of new enterprises such a procedure would often render profits and progress impossible. Thus a special machine might be a very valuable and profitable investment to a going concern, but would be worth scrap value only, at a forced sale, the day after it was built. For these reasons the rates of depreciation usually adopted lie between these two extremes, thus compro-

mising the advantages and defects of both, the rates being selected so as to lean toward either extreme, as desired, depending on the character of the asset under consideration.

Thus, referring to Fig. 14, suppose a milling machine that cost $3000 is to be depreciated to a sales value of $600 in ten years. If it be desired to depreciate the asset very rapidly so as to reduce

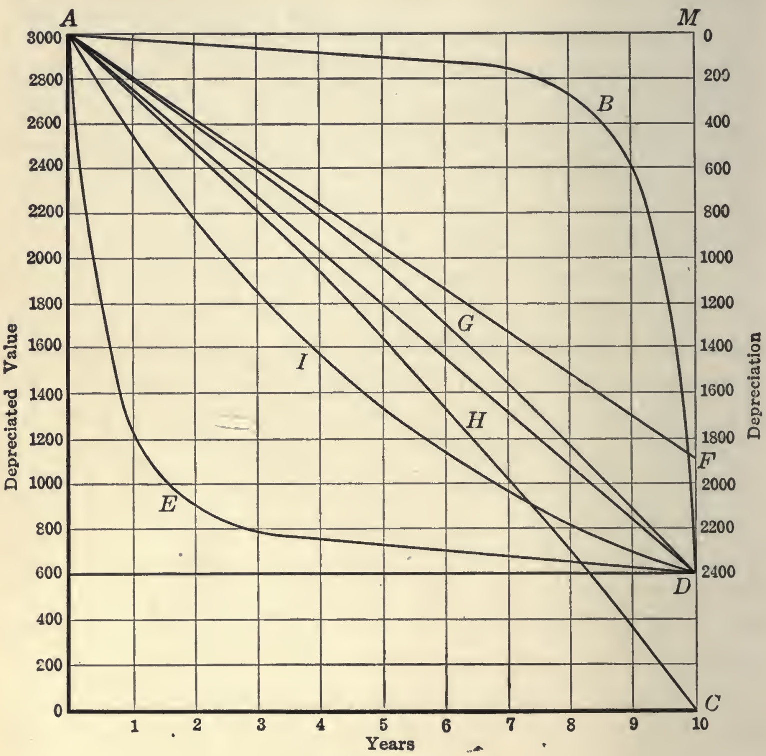

FIG. 14.

it quickly to forced sale value the depreciated value would lie along some such curve as AED, dropping rapidly in the early years and more slowly in the later years. If, however, the inventory was to be based upon the service value and the asset was kept in good repair, the depreciated values would lie along some such curve as ABD, falling very slowly at first, but dropping very rapidly as the machine neared the end of its productive

life. Obviously, an infinite number of curves could be drawn between these extremes depending on the circumstances and the judgment of the appraiser. In practice, however, it is customary, for convenience, to adopt some systematic mathematical method for progressively lowering the value of the asset, the most important of these methods being the **percentage-on-original-cost plan,** the percentage on **diminishing-value plan** and the **sinking-fund plan.**

Under the percentage-on-original-cost method the total depreciation, that is, the difference between the cost and the scrap values, is divided by the estimated producing life, and an amount equal to the dividend is deducted from the value of the asset annually. Thus, in the above example, the annual depreciation of the milling machine would be $\frac{\$3000\text{-}\$600}{10} = \$240$, and the depreciated values of the machine would lie along the straight line AD Fig. 14; hence the name **straight-line method** sometimes applied to this plan of depreciation. Because of its simplicity and because it gives a fair compromise between the conflicting difficulties discussed, this method of depreciation is used more, perhaps, than any other.

An argument in favor of the above method is that in a new business, with scanty income during the early years, it does not make such a heavy demand on income as other methods to be described. An argument against the above method is that depreciation really is much greater in the early years of an asset than in the later periods. Undoubtedly, the diminution in value of a machine tool is much greater during the first or second year of its life than during the tenth or fifteenth. Another argument against the system is that it is often more desirable to depreciate heavily during the early years when repairs and renewals are not costly, and to deduct less during the later years when repairs and renewals begin to be more burdensome, thus keeping the annual deduction from revenue fairly constant.

For these and other reasons some managers prefer the percentage-on-diminishing-value method. Under this method a fixed percentage is taken from the value as depreciated the preceding

year, and not from the original value. Thus, if the percentage of depreciation be taken at 15 the value of the tool at the end of succeeding years will be as shown by the curve *AID* Fig. 14. The method of depreciation by percentage on diminishing values evidently enforces a heavier reduction in value in the early life of the asset and in the case of an entirely new enterprise this method may make profits impossible unless a very long producing life is assumed. It is applicable particularly where it is desired to make a rapid reduction in the value of an asset of perishable or short-lived character.

Table I gives the comparative values and the amounts of depreciation by these methods for the case noted above. It will be noted that the annual amounts set aside are much greater in the percentage-on-diminishing-value method during the earlier years and less in the later years. Table 2 gives the depreciated value of unity for different rates and terms of years by the percentage-on-diminishing-value method, and may be found useful in assigning a rate of depreciation for an assumed working life.

TABLE 1. — COMPARISON OF METHODS OF DEPRECIATION.

Time.	By percentage on original value.		By percentage on diminishing value.	
	Value at time noted.	Amount of dep.	Value at time noted.	Amount of dep.
Beginning	3000	....	3000	....
End of 1st year	2760	240	2550	450
" " 2nd year	2520	240	2168	382
" " 3rd year	2280	240	1843	325
" " 4th year	2040	240	1567	276
" " 5th year	1800	240	1332	235
" " 6th year	1560	240	1132	200
" " 7th year	1320	240	962	170
" " 8th year	1080	240	818	144
" " 9th year	840	240	695	123
" " 10th year	600	240	591	104
Total amount written off	....	2400	....	2409

TABLE 2. — DEPRECIATED VALUE OF UNITY AT DIFFERENT RATES FOR TERMS OF YEARS.

Years.	1%.	1¼%.	1½%.	2%.	2½%.	3%.	4%.	Years.
0	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	0
1	0.990,000	0.987,500	0.985,000	0.980,000	0.975,000	0.970,000	0.960,000	1
2	0.980,000	0.975,156	0.970,225	0.960,400	0.950,625	0.940,000	0.921,600	2
3	0.970,299	0.962,967	0.955,671	0.941,192	0.926,859	0.912,673	0.884,736	3
4	0.960,596	0.950,930	0.941,336	0.922,368	0.903,688	0.885,292	0.849,346	4
5	0.950,990	0.939,043	0.927,216	0.903,921	0.881,099	0.858,734	0.815,372	5
6	0.941,480	0.927,305	0.913,308	0.885,843	0.859,068	0.832,972	0.782,757	6
7	0.932,066	0.915,714	0.899,608	0.868,126	0.837,591	0.807,982	0.751,477	7
8	0.922,745	0.904,267	0.886,114	0.850,763	0.816,652	0.783,743	0.721,389	8
9	0.913,517	0.892,964	0.872,822	0.833,748	0.796,235	0.760,231	0.692,534	9
10	0.904,382	0.881,802	0.859,730	0.817,073	0.776,329	0.737,424	0.664,832	10
11	0.895,338	0.870,779	0.846,834	0.800,732	0.756,921	0.715,301	0.638,239	11
12	0.886,385	0.859,895	0.834,131	0.784,717	0.737,998	0.693,842	0.612,709	12
13	0.877,522	0.849,146	0.821,619	0.769,023	0.719,548	0.673,026	0.588,201	13
14	0.868,746	0.838,532	0.809,295	0.753,643	0.701,559	0.652,836	0.564,673	14
15	0.860,059	0.828,050	0.797,155	0.738,570	0.684,020	0.633,250	0.542,086	15
16	0.851,485	0.817,699	0.785,198	0.723,798	0.666,920	0.614,253	0.520,402	16
17	0.842,943	0.807,478	0.773,420	0.709,323	0.650,247	0.595,825	0.499,586	17
18	0.834,514	0.797,385	0.761.819	0.695,136	0.633,991	0.577,950	0.479,603	18
19	0.826,169	0.787,417	0.750,391	0.681,233	0.618,141	0.560,612	0.460,419	19
20	0.817,907	0.777,574	0.739,135	0.667,609	0.602,572	0.543,794	0.442,002	20
21	0.809,728	0.767,855	0.728,048	0.654,245	0.587,620	0.527,300	0.424,332	21
22	0.801,631	0.758,257	0.717,128	0.641,171	0.572,930	0.511,655	0.407,349	22
23	0.793,615	0.748,778	0.706,371	0.628,348	0.558,606	0.496,306	0.391,055	23
24	0.785,678	0.739,419	0.695,775	0.615,781	0.544,641	0.481,416	0.375,413	24
25	0.777,822	0.730,176	0.685,338	0.603,466	0.531,025	0.466,974	0.360,396	25
26	0.770,043	0.721,049	0.675,058	0.591,396	0.517,749	0.452,965	0.345,980	26
27	0.762,343	0.712,036	0.664,932	0.579,568	0.504,806	0.439,376	0.332,141	27
28	0.754,720	0.703,135	0.654,958	0.567,977	0.492,185	0.426,194	0.318,855	28
29	0.747,172	0.694,346	0.645,134	0.556,618	0.479,881	0.413,408	0.306,101	29
30	0.739,701	0.685,667	0.635,457	0.545,485	0.467,884	0.401,006	0.293,857	30
40	0.688,972	0.604,622	0.546,321	0.445,701	0.363,232	0.295,711	0.195,366	40
50	0.605,006	0.533,157	0.469,689	0.364,171	0.281,988	0.218,065	0.129,885	50

TABLE 2. — *Continued.*

Years.	5%.	6%.	7½%.	10%.	12½%.	15%.	20%.	Years.
0	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	1.000,000	0
1	0.950,000	0.940,000	0.925,000	0.900,000	0.875,000	0.850,000	0.800,000	1
2	0.902,500	0.883,600	0.855,625	0.810,000	0.765,625	0.722,500	0.640,000	2
3	0.857,375	0.830,584	0.791,453	0.729,000	0.669,922	0.614,125	0.512,000	3
4	0.814,506	0.780,749	0.732,094	0.656,100	0.586,182	0.522,006	0.409,600	4
5	0.773,781	0.733,904	0.677,187	0.590,490	0.512,909	0.443,705	0.327,680	5
6	0.735,092	0.689,870	0.626,398	0.531,441	0.448,796	0.377,149	0.262,144	6
7	0.698,337	0.648,478	0.579,418	0.478,297	0.392,696	0.320,577	0.209,715	7
8	0.663,420	0.609,569	0.535,962	0.430,467	0.343,609	0.272,490	0.167,772	8
9	0.630,249	0.572,995	0.495,764	0.387,420	0.300,658	0.231,617	0.134,218	9
10	0.598,737	0.538,616	0.458,582	0.348,678	0.263,076	0.196,874	0.107,372	10
11	0.568,800	0.506,299	0.424,188	0.313,811	0.230,191	0.167,343	0.085,899	11
12	0.540,360	0.475,921	0.392,374	0.282,429	0.201,418	0.142,232	0.068,720	12
13	0.513,342	0.447,366	0.362,946	0.254,186	0.176,240	0.120,905	0.054,976	13
14	0.487,675	0.420,524	0.335,725	0.228,768	0.154,210	0.102,770	0.043,981	14
15	0.463,291	0.395,292	0.310,546	0.205,891	0.134,934	0.087,354	0.035,184	15
16	0.440,127	0.371,575	0.287,255	0.185,302	0.118,067	0.074,251	0.028,148	16
17	0.418,200	0.349,281	0.265,711	0.166,772	0.103,309	0.063,113	0.022,518	17
18	0.397,214	0.328,324	0.245,782	0.150,095	0.090,395	0.053,646	0.018,014	18
19	0.377,354	0.308,624	0.227,349	0.135,085	0.079,096	0.045,599	0.014,412	19
20	0.358,486	0.290,107	0.210,297	0.121,577	0.069,209	0.038,760	0.011,529	20
21	0.340,562	0.272,701	0.194,525	0.109,419	0.060,558	0.032,946	0.009,223	21
22	0.323,533	0.256,358	0.179,936	0.098,477	0.052,988	0.028,004	0.007,379	22
23	0.307,357	0.240,958	0.166,441	0.088,629	0.046,365	0.023,803	0.005,903	23
24	0.291,989	0.226,501	0.153,957	0.079,766	0.040,569	0.020,233	0.004,722	24
25	0.277,390	0.212,911	0.142,411	0.071,790	0.035,498	0.017,198	0.003,778	25
26	0.263,520	0.200,136	0.131,730	0.064,611	0.031,061	0.014,618	0.003,022	26
27	0.250,344	0.188,128	0.121,850	0.058,150	0.027,178	0.012,425	0.002,418	27
28	0.237,827	0.176,840	0.112,711	0.052,335	0.023,781	0.010,562	0.001,934	28
29	0.225,935	0.166,230	0.104,258	0.047,101	0.020,808	0.008,977	0.001,547	29
30	0.214,639	0.156,256	0.096,439	0.042,391	0.018,207	0.007,631	0.001,238	30
40	0.128,512	0.084,162	0.044,225	0.014,781	0.004,790	0.001,502	0.001,133	40
50	0.076,945	0.045,331	0.020,281	0.005,154	0.001,260	0.000,296	0.001,014	50

In the sinking-fund method of providing for depreciation a sum of money is set aside annually such that at compound interest it will accumulate,[1] by the end of the producing life of the asset, an amount equal to the original cost of the asset less its scrap or sales value. Thus, in the foregoing example, if $190.80 is set aside annually at five per cent interest, it will accumulate at the end of the ten years to a total of $2400. This method is shown graphically in Fig. 14 where the curve *AGD* represents the depreciated value of the same machine by this method, the vertical ordinates between the line *AM* and the curve *AGD* being the total of the sums set aside annually plus the accumulated interest. It is apparent that this method depreciates the asset less in the early years than either of the other methods.

While apparently this method differs from the straight line method, it is in reality identical in principle. In both cases a fixed amount is set aside annually, but in one case it is retained in the business as part of the working capital, while in the other it is set aside in a bank or some interest-producing investment. In Fig. 14 the line *AF* indicates the progressive sum of the amounts set aside annually for a sinking fund for the above case, while the vertical distances between *AF* and *AGD* measure the accumulated interest. In a similar way, if the sums of money retained annually from profits in the straight-line method be considered as earning only as much as that set aside in the sinking-fund method, the accumulated interest will be shown by the line *AHC* and it will be noted that the required depreciation of $2400 would be accumulated between the eighth and ninth years. In many instances it may be desirable and necessary actually to set aside a sinking fund as a guarantee against contingencies or obligations, especially where diverse interests are concerned in the distribution of the profits. On the other hand, it does not seem to be a good financial policy for a private concern to set aside earnings to draw interest at bank rates when, by retaining them in the business, a greater interest can, presumably, be earned. For if the business cannot earn more

[1] For annuity tables giving accrued values of annual payments at various rates of interest, see Kent's Engineer's Pocket Book, and handbooks generally.

than bank interest, it might as well be out of existence so far as profit producing is concerned.

Furthermore, the accounting of the sinking-fund method as usually applied to depreciation may be faulty. The problem of depreciation is to set aside from revenue an amount equal to the diminution in value that *has already occurred.* As has been noted, the exact rate at which depreciation occurs is difficult to fix; but it is clear that if the depreciation is really \$240 annually instead of \$190.80, the former amount should be set aside and the asset depreciated accordingly. The final total depreciation will, of course, be the same in the above case for all the methods discussed, but if the asset considered is one that wastes rapidly, its real value at any other time than the end of the working life will be more accurately expressed, perhaps, by a curve such as AID than by AGD. Sinking-fund methods are, therefore, more universally applicable to the problem of writing off intangible assets such as patents, franchises, development, expenses, etc., and for meeting definite obligations at a definite future time and where the intervening values are not so important.

As before noted, there are other methods of depreciation in use, some of which are simple and may be very satisfactory for certain circumstances though their basic principles may be arbitrarily chosen. The following method given by W. M. Cole [1] may be taken as an illustration. In this method the depreciation is calculated by multiplying the **wearing value** (original cost minus scrap value) by a fraction, the numerator of which is the remaining number of years of life the machine is estimated to possess, and the denominator the sum of the year numbers of the total estimated producing life. Thus, in the example quoted above, the estimated total life is 10 years and the denominator is, therefore,

$$10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 = 55,$$

and the numerator for the first year is 10, for the second 9, for the third 8, and so on. The depreciation at the end of the first year would be $(3000–600) \times \frac{10}{55} = \$436$; at the end of the second

[1] Accounting and Auditing, by W. M. Cole, p. 273.

year it would be (3000–600) $\times \frac{9}{55}$ = \$393, and so on. The depreciation applied by this method is as heavy, or heavier, during the earlier years than that computed by percentage on reduced value, and the method should, therefore, be used with caution unless it is desired to obtain a heavy depreciation during the early years of the asset..

93. Classification and Rates of Depreciation. In practically all enterprises the character of the several assets and their rate of depreciation vary greatly, and due account must be taken thereof. A flat rate of depreciation over the entire plant may, of course, be safe so far as allowing for *total* depreciation is concerned, but seldom gives any indication of the manner in which it should be distributed. A careful classification should, therefore, be made of all capital accounts and these again subdivided in such detail as will allow of intelligent depreciation rates. The following is a typical classification of factory equipment: — **Preliminary expenses, goodwill, land, buildings, power house machinery** (engines, boilers, etc.), **fixed plant and machinery, small loose plant, horses** and **terminable assets,** such as mineral deposits or leases.

The treatment of these several classes will depend very greatly on circumstances, and nothing more than general suggestions can be offered. To be on the safe side, however, the manager must shape his course by trying to reduce the book value of his plant to what it would actually bring in the market, this value being usually much less than the cost price or even than the actual value of the plant as a "going concern." With this in mind all irrecoverable expenses such as preliminary legal expenses, surveys, etc., and all unsaleable assets, such as foundations, will be written off as rapidly as possible. The same remarks apply, usually, to such short-lived assets as patents and goodwill. It is comparatively unusual, today, to find that the land occupied by a factory needs to be depreciated. Land values are, in most localities, on the increase, but an appreciation of value of the land occupied by a factory should be discounted if the remodelling of the site for other purposes involves the removing of massive foundations, chimneys, etc.

The rate of depreciation for buildings will, of course, vary considerably with the character of construction and the work that they house. Thus, heavy stone and brick buildings used for storehouses will far outlast cheap wooden or even steel frame buildings used for such severe service as forge shops, or industries requiring the use of heavy cranes that severely rack the framework. Again, the life of machinery will depend on the excellence of its original construction and the service to which it is devoted. A portable hoisting engine would not be expected to last as long as a Corliss engine in a well-kept engine room; and a large boring mill, if used infrequently, will outlast many renewals of small tools.

The following list (Table 3)[1] may be taken, therefore, as giving average values, only, for buildings and machinery kept in a fair state of repair, and *including obsolescence.* Column four gives the rate that must be applied by the percentage-on-original-cost method to reduce this original cost to the residual value noted in column two during the estimated life of the asset. Column five gives corresponding rates for the method of percentage on diminishing values. It will be noted that these last rates are, as a whole, much higher than the former. While it may be *desirable,* as before noted, to depreciate very heavily in the early years of the life of the asset it is often not so *expedient,* and actual depreciation rates even if based on the principle of diminishing values are usually lower than those given in column five, the difference often being compensated for by renewals and extensive repairs, thus practically extending the life of the asset.

Engineering expenses for production, drawings and patterns should, when possible, be charged to specific production orders. Where this is impossible, as in the case of the development of a *line* of machines, such expenses should be carried to a **development account** and charged off over a definite number of machines. Particular care should be used in crediting patterns as an asset.

[1] For a detailed list of depreciation factors and estimated length of life of various properties, see Engineering Valuation of Public Utilities and Factories, by Horatio Foster, p. 194, or Valuation of Public Utility Properties, by Henry Floy, page 188.

TABLE 3. — ESTIMATED LIFE AND FACTORS OF DEPRECIATION.

Character of asset.	Probable life of asset in years.	Ratio of scrap value to original value.	Percentage on original cost.	Percentage on diminishing value.
Brick or steel-frame buildings, easy service	40	0.10	2.25	5.5
Brick or steel-frame buildings, severe service	20	0.10	4.5	11
Good wooden buildings, easy service	30	0.10	3	7.5
Good wooden buildings, severe service	15	0.10	6	14
Steam engines	15 to 30	0.10	6 to 3	14 to 7.5
Steam boilers	15 to 30	0.10	6 to 3	14 to 7.5
Boiler-room feed pumps	20	0.05	4.75	14
Engine room instruments and gauges	10	0.05	9.5	26
Steam-piping, valves and fittings	10 to 15	0.05	9.5 to 6.3	26 to 18
Portable engines and boilers	10	0.05	9.5	26
Gas engines	10 to 15	0.05	9.5 to 6.3	26 to 18
Turbo-generators	20 to 30	0.10	4.5 to 3	11 to 7.5
Electric generators	20 to 30	0.10	4.5 to 3	11 to 7.5
Electric motors	20	0.10	4.5	11
Storage batteries	10	0.05	9.5	26
Switchboard and instruments	15	0.05	6.3	18
Heavy machine tools	25	0.10	3.6	9
Light machine tools	15 to 20	0.10	6 to 4.5	14 to 11
Shafting, hangers and pulleys	20 to 30	0.05	4.75 to 3	14 to 9
Belting	10 to 25	0	10 to 4.0	....

If used frequently, they soon wear out, and if not used, they are not only of little value but often occupy valuable storage space that could be used for other purposes. Metal patterns, of course, have an intrinsic residual value.

Small, loose plant such as hand tools, chains, ropes, foundry flasks, etc., wear out so rapidly that they should be carried at a very low value. The better way to consider much of the small, loose plant is to renew it entirely out of revenue and charge it off as expense. Horses should also be carried at a nominal value because of their perishable character. Terminable asset, such as mineral deposits, leases, loans, etc., are best cared for by means of a sinking fund as explained in Art. 92.

A complete inventory should be maintained listing all buildings, machinery and tools. This inventory is most conveniently formed on the card index or loose leaf principle, a card or leaf being provided for each item. Fig. 15 illustrates such a card, and it will be noted that it gives a life history of the machine, including original cost, weight, location, residual value, rate of depreciation, repairs and additions, and also the history of any special attachments that may have been used with it. Records of this kind constitute a **plant ledger.** A ledger may be maintained for standard plant and one for special fixtures if desired. The plant ledgers with the cost accounts, the stores and stock ledgers constitute an inventory of the material assets of the plant.

94. Investment and Distribution of Depreciation. It is clear that the setting aside of funds out of revenue to compensate for depreciation is equivalent to transferring a part of the fixed assets to the floating assets, the total value of the assets remaining unchanged if the computations are correctly made. The primary object of this reserve is to provide for repairs and replacements, and if not needed for this purpose it may be employed elsewhere in the business; or, if not needed thus, it should, of course, be invested so that it will be earning interest. The relation between depreciation, repairs and capital account has been discussed already in Art. 91 and the principles therein noted should be carefully observed in making "betterments" which may be either repairs, additions to capital or a combination of both. Generally speaking, all prosperous enterprises tend to grow in size (See Art. 21) and if earnings set aside for depreciation are used to extend the plant, care should be taken that such additions are not credited to the capital account if their value is offset elsewhere by uncared-for deterioration.

Depreciation, as has been noted, is a just charge against production and should, properly, be included in the manufacturing expenses and distributed with them. The somewhat common practice of fixing costs without including depreciation, trusting to profits being large enough to declare a dividend after deducting depreciation, cannot be considered a safe policy, especially where the books are closed but once a year. The

STANDARD PLANT LEDGER	
MACHINE *24" x 8' LATHE*	LOCATION: FLOOR *2* ROW *8* NUMBER *46*
MAKER *REED MFG. CO.*	COST *$1000*
PURCHASED *2 - 12 - 1900*	ESTIMATED LIFE *20* YEARS
NEW OR SECOND HAND *NEW*	PROBABLE SELLING VALUE *$200*
WEIGHT *4040* POUNDS	RATE OF DEPRECIATION *8%*

DEPRECIATED VALUE AT END OF YEAR

'00	*920*	*00*	*'05*	*606*	*35*
'01	*846*	*40*	*'06*	*623*	*14*
'02	*778*	*69*	*'07*	*548*	*23*
'03	*716*	*39*	*'08*	*504*	*41*
'04	*659*	*08*	*'09*		

REPAIRS AND ALTERATIONS AFFECTING DEPRECIATION

DESCRIPTION	ORDER	DATE	CREDIT		DEBIT		DESCRIPTION	ORDER	DATE	CREDIT	DEBIT
GENERAL REPAIRS	*2468*	*6-20-06*	*65*	*30*							
TAPER ATTACHMENT	*SOLD*	*4-3-07*			*25*	*00*					
NEW CHUCK		*3-6-08*	*50*	*00*							

FOR COST OF INSTALLATION AND ATTACHMENTS SEE REVERSE SIDE

FIG. 15.—STANDARD PLANT LEDGER. Hand-recorded Information is indicated by *Italics*.

argument may be used that to include depreciation in factory costs might raise the total cost above the market price, and that it is better to wait till the end of the year to see what allowance can be made for depreciation. This argument is, of course, fallacious. *Cost* is *cost*, and the manufacturer that has included all items of cost in his manufacturing expenses can see much more clearly where he must *reduce manufacturing costs* to meet competition, and the manufacturer that can meet competition is the one that will eventually survive. The practice of including depreciation in the general expense as a percentage of the total wasting assets is, of course, safe so far as *total* costs are concerned, but all the arguments in Articles 72 and 81 regarding the distribution of expense in a scientific manner apply also to depreciation; and with advances in cost-keeping methods, this item of expense will be distributed more as a machine rate and less as a uniform percentage on labor or time elements of cost. In continuous industries it is easy, of course, to charge off depreciation. Thus in cement mills it is common practice to add a certain amount per barrel or sack to care for this item, but, as noted in Article 83, when manufacturing processes become more complex, the problem is more difficult and requires careful consideration. Each department should, if possible, bear its own share of depreciation and one line of goods should not be burdened with the wear and tear or obsolescence charges belonging to another.

95. Conclusion. In concluding this brief outline of the principles of depreciation it may be well to repeat that it is seldom possible to lay down exact rules for any kind of a plant. Conditions change from year to year; the machine or process that is valuable today is obsolete tomorrow, and the state of trade may and usually does modify greatly what may be a very desirable course of procedure. In dull times it may not be possible to depreciate as fully as desired, and in good times it may be desirable to make a greater allowance than might be really necessary under normal conditions. However, the fact remains that depreciation is an important expense that cannot be neglected and a well-defined system even though it cannot be rig-

idly adhered to, will assist materially to a clearer understanding of the problem. The slower the deterioration the more important it is that depreciation be executed *systematically* since, where the life is short, renewals from revenue are more frequent and force themselves upon the attention of the manager. Long-lived assets, therefore, need more careful consideration in order that the accumulated uncared for deterioration of years may not be the means, as it often is, of wrecking the enterprise.

References:

The Depreciation of Factories, by Ewing Matheson.

Engineering Valuation of Public Utilities and Factories, by Horatio A. Foster.

Depreciation and Wasting Assets, by P. D. Leake.

The Depreciation of Plant, by H. M. Norris. Engineering Magazine, Number 16, 1899, p. 812 and 957.

Valuation of Public Utility Properties, by Henry Floy.

CHAPTER XI.

THE COMPENSATION OF LABOR.

96. Basic Features. It is almost axiomatic that the industrial problems dealing with materials, machinery and the physical side of industry are relatively important only as they bear on the greater problems of human existence, and for this reason the problem of rewarding men for services rendered is by far the most important and at the same time the most difficult of all industrial problems. This is necessarily so because it bears so directly on the great problem of distribution of wealth, and because it touches so closely upon human nature with all its ambitions, hopes, and fears. The problem has been with man from the beginning, changing in aspect as he has changed his methods and ideals, and will probably continue to be with him to the end.

It was inevitable that the changed industrial methods discussed in the foregoing chapters, with the changed personal relations resulting therefrom, should bring with them new methods of compensating labor. Under the older and simpler methods the relations between master and man were personal and often very close. The apprentice, and sometimes the mature workman, was often treated like a member of the employer's family, a relation that now survives only in a few callings, such as agricultural service. Nor was this relation wholly lost even after the introduction of modern tools began to specialize men, so long as the number employed by any one man was comparatively small. Furthermore, under the simpler methods, where the tools of industry were within comparatively easy reach of all and especially in this country where congested populations had not yet appeared, where land was still plentiful and the avenues to all industry still easily accessible, the law of supply

and demand was much more effective in regulating the compensation of labor than at present.

As the new methods advanced and aggregation and specialization became more effective, these simple relations were obliterated. As explained in Articles 29 and 30, these influences constantly tend to separate men into classes and as numbers increase, the workman is separated farther and farther from the employer, till today, in all large industries, labor has lost all personal attributes and appears to the employer as a commodity to be purchased at the lowest market price. True, the employer is as interested, and perhaps more so than ever, in securing efficient help, but the securing of this help is delegated to others and the working agreement is based on strict business principles with little or no personality entering into the bargain. As competition became keener the employer found that he must either improve his methods or cut his wage rates. The first became increasingly difficult and was often impossible, while the latter always appeared to be a natural and defendable procedure under the old day rate system of compensation. The idea of obtaining increased output by increased pay came as a later development of the study of labor compensation.

The workman, on the other hand, cut off from the ownership of his tools and finding himself increasingly dependent on the employer for his daily bread, brought face to face daily with new labor-saving machinery, and observing the degradation of labor that nearly always followed its introduction, most naturally set up what defences he could against these tendencies that carried him toward an ever decreasing compensation. As the individuality of the worker was lost in that of the class (See Art. 30), organization against common danger was most easy and natural. Labor unions are a most natural result of our changed industrial methods. They cannot be legislated out of existence but will, like their prototypes, the old guilds, persist till the causes of their growth are removed by radical changes in our industrial organization.

As a net result of these changes labor compensation is no longer a simple matter based on the law of supply and demand,

but is more likely to be based on a sharp bargain driven between two opposing parties with many complex and confusing conditions that tend to modify this law or render it at least very sluggish in its action. It is this very complexity of influences that makes the labor problem so difficult of solution because it renders exact information difficult to obtain. A continued struggle between organized labor demanding all that it can get and organized capital banded together to oppose stubbornly the demands of labor cannot be expected to result in a solution of the problem. If there is hope of a peaceful solution it must lie in a systematic and scientific investigation of the *facts* of each case; and if contending parties cannot settle their differences amicably on such a basis, communal control of some kind will undoubtedly enforce a settlement or suggest a remedy. It should be particularly noted, however, that legislative action, boards of arbitration or any other communal instrument cannot be expected to render satisfactory decisions that will be permanent till much more is known of the exact facts concerning labor than is usually available at present. Anything approaching a comprehensive study of this interesting problem is beyond the scope of this treatise, but the discussion of the wage systems that follows may make the above points clearer.

To the manufacturer, whose capital investment in machines is large, the question of wages has much greater importance than their numerical value would indicate. The wages of a machine operator may not be great, but the output of the machine he controls may be very great, and any failure or slackness on his part may be reflected many fold in the decreased production of his machine. It does not pay, therefore, to have inefficient men operating expensive machines, where effectiveness or deficiency on the part of the workman is multiplied many fold in the product. And, furthermore, as a perfectly general principle, the more efficient the workman the greater will be the output for a fixed capital investment and fixed conditions of production. And this output will be obtained at lower unit cost since it will be obtained without appreciable additional burden, since burden in general does not vary in proportion to output but tends to

remain constant through a considerable range of variation of output. It is clear that low paid workmen may not always be the cheapest; in fact, a low rate of pay is likely to indicate a low rate of output. This idea forms one of the basic features of modern pay systems that recognize the importance of obtaining the best results out of every man even though increased compensation is necessary to secure this result.

97. The Primary Pay Systems. There are only two fundamental methods of rewarding labor; one is by paying the man for the amount of *time* that he spends on the work and the other by paying him for the *amount of work* that he performs. The first method is usually characterized as **day work** because the rate of pay is most usually by the day, or *per diem*. The second is usually called **piece work** since compensation is by the piece or job. All other wage systems are combinations of these two principles in varying proportions. Some of these combinations are occasionally termed **profit-sharing systems** because of certain *gain-sharing* features that are incorporated in them. This is erroneous in two particulars. No money paid out directly as a reward of labor can by any stretch of imagination be classed as profit which is always an undistributed balance after all costs of production are paid in full. Nor can any money distributed as profit be considered as a wage payment, for the same reason. Profit-sharing schemes are in the nature of an extra reward, not only for skill and industry, but for faithfulness of service over some considerable period of time, usually a year. **Gain-sharing** is a correct name for the new pay systems, to be described, such as premium and bonus systems, for the element of gain-sharing is embodied in them; but they are, nevertheless, combinations of the two primary systems named above.

Day Work.

98. General Features. Under the day-work system of wages the employer buys the *time* of the worker. The unit of time bought may vary from one hour to a year so that the term day work is, in a way, a misnomer, handed down to us from the time when the day was a more common unit for wage payment. The

higher the grade of the employee the longer, as a rule, is the time unit. Thus managers, treasurers and higher officials are usually engaged by the year, though most usually paid by monthly installments. Foremen and engineers may be hired by the month, other classes by the day or hour. As the unit of time bargained for becomes greater the less supervision, presumably, is needed to obtain value received, since the men on monthly or yearly salaries are, usually, not numerous, comparatively, and are selected with a view to being enough interested in their work, or what is more likely, loaded with enough responsibility to insure good service.

The method of day work is, without doubt, the oldest method of rewarding labor and the reason for its inception is not difficult to see. In the beginning of any civilization industry is simple and *general.* The farm hand was required to do many and diverse duties, each one occupying, perhaps, a short portion of his daily service which was not limited to definite hours but set in accordance with the necessities of the case. Domestic service of to-day is an excellent example of this form of employment of which only a few types have survived. Much of the early manufacturing industry was of this same general character. A machinist of fifty years ago was expected to do all manner of work on a large range of machines working, perhaps, on many jobs in the same day. Taking into account the more or less paternal attitude of the old employer toward his workman, the day-work method was a very natural system and not without its advantages. Where the number of men employed was small and personal relations close, the employer was able to reward diligence and skill in something like a just proportion; and he depended on personal observation, either on his own part, or through the use of not more than one intermediary, to insure a fair return from each man for the wages paid. The personal element was a large factor, and there was always the hope for the abler men that through industry they might rise either to a higher paid position, or get into business for themselves.

99. Defects of the Day-work Method. As the influences of aggregation and specialization began to make themselves felt,

and the personal relations vanished, the day-work method became less and less applicable. As the personality of the workman was merged by these influences into that of a class it became more and more difficult for the individual to make his superior qualities known and more and more difficult for the employer to reward industry and skill in adequate proportion. The employer ceased to *hire men*, as men, and began to *buy labor* like any other commodity. The inevitable result was that the better men, unable to obtain higher pay than their more inefficient fellows, organized their class and endeavored to raise the wage level of the entire class as the only means of obtaining the desired compensation.

On the other hand workmen on day pay had great opportunity of restricting output, even in spite of rapid advances in machinery since, as will presently appear, little was known as to the possibilities of production with the new tools. The workman, instinctively feeling that he could influence the law of supply and demand in his favor by limiting the output,[1] did not work up to his capacity and under these circumstances production tended to mediocrity or even to the standard of the poorer workman. Any efforts to *drive* men to higher output are almost invariably met by stubborn organized class resistance, while the employer who pays only the rate earned by the poorest man may get only the output he pays for, even from his very best men.

Day work, therefore, has often proved inadequate and unfair both to employer and employee in modern mass production involving large numbers of men and specialized labor. It is a system that is adapted naturally to *general work* and even here in its simplest form is fully adequate for small numbers only. It will remain in use, however, in many places where it is and

[1] The workman should not be censured for this tendency. Self-preservation is the first law of nature. With the most apparent effects of the new system staring him in the face and his economic independence taken from him, it is not to be expected that he would be willing to suffer any present loss because, economically, future generations would be benefited. It must be remembered that the economic benefits resulting from new methods do not always accrue to those directly interested in the industry affected (See Art. 9).

where it is not suitable, simply from its inertia. Mr. Gantt[1] has very ably pointed out how its usefulness and effectiveness may be extended by separating each man's work from his neighbor's and by keeping a careful record of individual performance, thus restoring, in a measure, the possibility of individual superiority and reward, and obtaining a clear and more accurate idea of the time actually required to do a given piece of work.

Piece Work.

100. General Features. In piece-work pay systems the man is paid for the *amount of work performed* and not for the time expended. Thus, suppose a man earning $3.00 per day was making bolts for his employer. His pay would not change under this day pay system whether he made ten or fifteen bolts daily. But suppose he were paid *by the bolt* at the rate of twenty cents[2] each. Then he must make fifteen bolts to earn $3.00. Any falling off in his production would mean lowered daily earnings, while any increase in his production would mean an increase in pay. If the rate per piece is fair to both employer and employee this would seem to be an ideal system in many ways as it apparently restores to the ambitious workman the opportunity to secure the increased compensation due him on account of his greater skill or diligence. If it successfully stimulates production it lowers the cost of the product, since the increased production is obtained with practically no increase in overhead costs. Thus, suppose in the above example that the material cost per bolt is 10 cents, and the machine rate[3] (See Art. 79) for the equipment he is using is $2.00 per day; then the cost per bolt to the employer for various rates of production would be as shown in Table 4.

[1] See Work Wages and Profits, p. 59.

[2] Piece rates are usually set somewhat lower than the corresponding day rate.

[3] The effect of including material cost and machine rates in total costs should be carefully noted. The first does not affect the *difference* in total costs but does affect their *ratio*. The second affects their difference as well. Costs that do not include labor, material and burden are misleading for purposes of comparison especially if compared with other costs where these items enter in different proportions.

TABLE 4. — EARNINGS AND COSTS UNDER PIECE WORK.

Number of bolts per day.	Material cost.	Workman's earnings.	Machine rate.	Total shop cost.	Cost per bolt.
10	1.00	2.00	2.00	5.00	0.50
15	1.50	3.00	2.00	6.50	0.43⅓
20	2.00	4.00	2.00	8.00	0.40
30	3.00	6.00	2.00	11.00	0.36⅔
40	4.00	8.00	2.00	14.00	0.35
50	5.00	10.00	2.00	17.00	0.34

The workman, therefore, makes a higher wage, the cost of the product is lessened, and the output per dollar of investment is increased so that both employer and employee are benefited.

Piece work is evidently not adapted to cases where many pieces of different character are handled daily. It lends itself naturally to repetitive work, that is, where many pieces of one kind are to be made. It can be applied to advantage, however, to small numbers of parts where the work to be done on each is of sufficient magnitude to make intelligent estimates of time allowances possible.

101. Difficulties and Objections. Piece work is of course not new, and has probably existed in some form or other from early antiquity. For reasons already discussed it did not, however, obtain a strong foothold in our industrial organization in the beginning. When the limitations of the day wage method discussed in Article 99 began to make competition more difficult and as the volume of production increased, employers naturally turned to the piece-rate system as a means of increasing production and reducing cost. These very limitations of the day wage, however, have been, in a large measure, the reason for one of the greatest difficulties in introducing piece rates. Under modern conditions the discouraging effects of day work had tended, as already noted, to reduce greatly the output so that with the advance in modern tools and methods little was really known regarding the possibilities of production or what really constituted a fair day's work. The records of work already accomplished were, therefore, unreliable as a guide in setting

piece rates, and the estimates of a busy foreman were likely to be little better than guesses.

When, therefore, piece rates were introduced, based on these unreliable sources, it was found that the workman under this stimulus could produce much more than it was supposed he could. An examination of the foregoing table (the data of which are taken arbitrarily but are fairly representative) shows that under these conditions the increase in wages is very much greater in proportion than the decrease in cost. The result was that the employer either from cupidity, or because he really believed the worker was obtaining more than a fair share of the returns, "cut" the piece rate to a lower figure.

If the new piece rate allowed of it, and if the ambition of the worker was not killed by the first cut, and he again succeeded in raising his wage to a high figure, the rate was again cut; and this cycle was repeated till the discouraged worker refused to exert himself farther and perhaps found himself working much harder than formerly with little or no advance in his salary.

The general effect of this penalizing process upon the good workman is to teach him to limit his production to that of the poorer man and to awaken class consciousness. He quickly sees that an advance in wages cannot come through his own extra exertions and he naturally turns to organization as a means of securing by might what he feels should be his by right; and he is willing that poorer men shall be overpaid in order that he may receive something near what he feels is his just due. The logic is perfectly clear and he cannot be blamed for the result.

Piece work has also been opposed upon other grounds. The average workman much prefers day pay because it involves no risk as to the amount he is to receive. In some respects there is a good reason for this objection. If the workman on day pay encounters extra hard castings or if his production is interfered with by reason of a break down or other unforeseen contingency over which he has no control, the entire loss occasioned thereby falls, not on him, but on his employer; while on piece work he would be a loser to the extent of his probable earnings. It has

been opposed by labor unions on ethical grounds,[1] because it is asserted that the system awakens greed in the worker and stimulates unrestricted competition between them, with the result that discord, suspicion and the destruction of brotherly feeling soon take the place of harmony and good will. While the truth of this assertion is denied by some, the writer knows by personal experience that there is a considerable amount of truth in the statement. Competition between workmen has the same effect as competition between employers or corporations, and this principle must often be taken into account in introducing new wage systems.

And, finally, the workman is prone to object to any method that tends to increase production, simply because it does tend to do so. He may not be able to explain just why, but as before noted, he instinctively feels that by restricting production he can affect the law of supply and demand in his favor. He is interested in his own welfare, and not that of the men of the future; hence economic arguments based on the ultimate gain accruing from increased production do not impress him. This attitude, short sighted as it may be, is reflected in union regulations that, while allowing the use of piece work, often fix a maximum number of pieces that any man may turn out in a day.

It will be noted that the defects and objections to piece work may be those due to bad management (including lack of accurate knowledge) or to inherent defects in the method itself. Piece work has been operated very successfully where the rates have been accurately set and have been maintained, and where a correct understanding existed between employer and employee. There are many cases where it can be used to advantage, but its success will depend on a careful observance of the advantages and disadvantages noted above.

[1] See Piece Work Not Necessary For Best Work In The Machine Shop, by James O'Connell, President International Association of Machinists, Engineering Magazine, Vol. 19, 1900, p. 373.

Contract System.

102. In some of the ship-yards, locomotive works and similar industries, both in Great Britain and America, a method known as the **contract system** or **contract plan** is in use to a considerable extent. Under this system the employer contracts with a gang boss to do a certain part of the work, as the building of a mast, the assemblying of the valve gear of a locomotive, or some similar comprehensive detail that may involve the employment of several workmen of various degrees of skill. The employer furnishes all materials and tools and the contractor provides his own workmen, paying them either by piece work or day work as they may agree between them. To the owner, therefore, the plan is simple piece work; while to the workman it may be either day work or piece work.

The advantages to the employer are obvious. He secures a definite cost on his product and, apparently, has the burden of labor disputes lifted from his shoulders. The contractor and his men have, however, little interest in the upkeep of the tools, and the wear and tear on equipment is likely to be heavy under this system. The condition of the workman under this method may or may not be advantageous, depending on the contractor, and while the plan has worked well in many places, the underlying principles cannot be said to be good, as it admits of the sweat-shop methods that have followed in its wake when used in callings such as the clothing trade.

The Halsey Premium Plan.

103. General Features. The Halsey Premium Plan [1] was the first of the modern gain-sharing plans and is a well thought out effort to meet some of the difficulties of day work and piece work already noted. It is especially important as it was the pioneer [2]

[1] See The Premium Plan of Paying For Labor, by F. A. Halsey, Trans. A.S.M.E., Vol. 12, p. 755.

[2] This is true, at least, so far as modern times and the machine industries are concerned. The idea seems to have been employed, however, in earlier days in other industries, but such use as was made of it had made little impression on wage systems in general. See also Rational Management by A. H. Church, Engineering Magazine, April, 1913, p. 29.

in a new method of rewarding labor. Under this plan it is optional with the workman whether he elects to work on the premium plan or not and his day's pay is assured to him whether he earns a premium or not, provided, of course, that he is not so incompetent as to be undesirable. Under this plan a standard time, *based on previous experience,* is allowed for the work in question. For every hour that the workman can shorten this time he is paid a fraction of his hourly wage as a premium. In Mr. Halsey's original illustration the fraction selected is one-third; but, as he points out, this is a question that must be settled by good judgment. In practice it varies from one-quarter to one-half of the hourly wage. Thus, suppose a job normally requires ten hours to complete, and the workman's pay is $3.00 for the ten hours. If he can reduce the time of the work to eight hours his premium will be $\frac{2 \times 30}{3} = 20$ cents and his earnings for the eight hours will be $(8 \times .30) + .20 = \$2.60$ or at the rate of $3.25 per day of ten hours. The labor cost to the employer is, therefore, forty cents less than on day work. Or suppose, again, that as in Article 100 the workman is paid $3.00 per day and is producing normally fifteen bolts daily. If under the stimulus of the premium plan he produces twenty bolts daily he would save one-third of a day in time and his bonus would be $(\frac{1}{3}\ \frac{300}{3}) = 33\frac{1}{3}$ cents, thus making his daily wage $\$3.33\frac{1}{3}$. The labor cost per bolt would also fall from 20 cents each to $16\frac{2}{3}$ cents. On the other hand if he should fail to make fifteen bolts he would still receive his full normal day's pay of $3.00. The wages and costs for various numbers of bolts under this plan would, thus, be as shown in Table 5, using the same data as in Article 100, and making the premium one-third of the labor value saved.

104. Advantages and Disadvantages. Since this system insures the workman his full day's pay it is easy to introduce. No changes are needed in the regular shop methods, or at least no conspicuous changes, and the workman is not compelled to work for a premium unless he so desires. Because of this conciliatory characteristic of the plan it is in more extended use than any

TABLE 5.—EARNINGS AND COSTS UNDER HALSEY PREMIUM PLAN.

No. of bolts.	Material cost.	Day wage.	Premium.	Workman's earnings.	Machine rate.	Total shop cost.	Cost per bolt.
10	1.00	3.00	0	3.00	2.00	6.00	0.60
15	1.50	3.00	0	3.00	2.00	6.50	0.43⅓
20	2.00	3.00	33⅓	3.33⅓	2.00	7.33⅓	0.36⅔
30	3.00	3.00	1.00	4.00	2.00	9.00	0.30
40	4.00	3.00	1.66⅔	4.66⅔	2.00	10.66⅔	0.26⅔
50	5.00	3.00	2.33⅓	5.33⅓	2.00	12.33⅓	0.24⅔

other gain-sharing method. It is simple in its operation and every man can compute just what his premium will be. The standard times are posted in the shop and each man by keeping account of his own performances can readily compute his own premium. These standard times, as before noted, are based on previous records with such shortening of these records as may seem desirable or necessary. However, no radical shortening of the records is made unless new methods or appliances are put in operation.

Under this plan the workman does not obtain the entire benefit of the gain in product that he produces as he does in straight piece work. There are two logical reasons for this. First, the employer is entitled to some of the gain, since the workman in making it uses the tools harder, uses more power and other incidentals. Secondly, since the employer is obtaining part of the gain he is less likely to reduce the premium and lower the workman's earnings as in piece work.

An argument often advanced against the plan is that the rates are set by judgment or are based on records that do not represent the workman's full capacity and that, as a consequence, the workman easily makes large premiums, thus tempting the employer to reduce the standard time. The same argument holds against piece work as ordinarily practiced. In the light of more modern advances in time study there is some truth in this criticism, but there is no reason why basic rates for this system cannot be based on so-called scientific time studies. On the other

hand the lowering of the standard time much below previous records makes the introduction of any bonus or premium plan more difficult. The success of the Halsey plan is due largely to its simplicity, ease of introduction and fairness.

105. The Rowan Modification of the Halsey Premium Plan. It is obvious that the general principle involved in the Halsey method can be modified and varied in many ways. One of the best known of these modifications is that of Mr. James Rowan [1] of Glasgow, Scotland. In this plan a percentage is added to the day rate, this percentage being computed by the fraction $\frac{\text{Time Saved}}{\text{Standard Time}}$, or expressed as an equation

$$\text{Premium} = \text{Day rate for time consumed} \times \frac{\text{Time Saved}}{\text{Standard Time}}.$$

Thus, if the standard time were ten hours and the day rate \$3.00 and the workman completed the job in eight hours, his premium would be $\$2.40 \times \frac{2}{10} = .48$ and his pay for the *piece* would be $\$2.40 + .48 = \$2.88$ or at the rate of \$3.60 per day. Using the same data as in the other systems the several items for various rates of production would be as shown in Table 6. Fifteen bolts per day are taken as a standard day rate production.

TABLE 6. — EARNINGS AND COSTS UNDER ROWAN PREMIUM PLAN.

No. of bolts.	Material cost.	Day wage.	Premium.	Workman's daily earnings.	Machine rate.	Total shop cost.	Cost per bolt.
10	1.00	3.00	0	3.00	2.00	6.00	0.60
15	1.50	3.00	0	3.00	2.00	6.50	0.43⅓
20	2.00	3.00	0.75	3.75	2.00	7.75	0.38¾
30	3.00	3.00	1.50	4.50	2.00	9.50	0.31⅔
40	4.00	3.00	1.87½	4.87½	2.00	10.87½	0.27⅕
50	5.00	3.00	2.10	5.10	2.00	12.10	0.24⅕

It will be noted that under this plan the earnings of the workman can never exceed twice his day rate. The value of the

[1] See A Premium System of Remunerating Labor, by James Rowan, Proceedings of Mechanical Engineers, (British), 1901, p. 865.

controlling fraction, $\frac{\text{Time Set} - \text{Time Consumed}}{\text{Time Set}}$ constantly approaches unity, as the time consumed approaches zero, hence the premium can never exceed the day rate multiplied by unity and therefore the earnings can never be more than twice the day rate. It also pays the worker more liberally for the earlier, and hence easier gains, but makes it increasingly difficult to make higher gains, thus practically discouraging very high production. This plan of computing the premium differs from the original Halsey method in this particular, as the latter places no limit to the continual increase of earnings. There seems to be no more reason for limiting earnings than for limiting production, but the plan has the advantage, if it may be so-called, of lessening the employers' desire to cut the basic rates as production and earnings increase. This plan has not been much used in this country though in extended use in England.

The Taylor Differential Piece-Rate.

106. General Features. All the pay systems previously discussed aim to secure increased production simply by enlisting the interest of the workman through increased compensation. None of these methods make any exhaustive effort to find out what really constitutes a fair basis for a day's work, and with the exception of the straight piece work plan, none of them penalizes the workman for not putting forth his best efforts. The Halsey premium plan paved the way, however, for a more thorough study of the problem, and the proposal of more refined methods. Whether these new methods are more equitable, and whether they will come into extended use will be discussed in a later chapter.

The first of these new methods was that proposed by Mr. F. W. Taylor.[1] Mr. Taylor began his investigation by ignoring all records based on previous performances and studied each operation in detail; his idea being to find the best method of doing each detail operation and the minimum time that should

[1] See A Piece Rate System, by F. W. Taylor, Trans. A.S.M.E., June, 1895.

be allowed to do it. He has shown that not only can this be done by expert observers, but also that by recording the results of these analytical observations for various operations it is possible to build up, synthetically, the minimum time required for other jobs involving these common details of operation. He has shown, also, that by surrounding the workman by expert advisors and the proper equipment he can be taught to reach the standard performances predicted by these expert observers. This point of view has been fully discussed in Chapter 9. This method, then, and those that follow presuppose more than a change in the pay system; they involve changes in management as well.

To encourage the workman to reach the standard of performance Mr. Taylor establishes two piece rates, a high piece rate when the standard is attained, and a low piece rate when the standard is not attained. Thus, if as before, the standard production is 30 bolts per day the piece rate for that output, and beyond it, might be fifteen cents per bolt; but for any production below thirty the rate might be ten cents per bolt. There is every incentive, therefore toward maximum production, for the workman receives not only a high piece rate if he reaches and exceeds the standard, but receives the full piece rate, per piece, as his production rises, after he has attained the standard performance and not simply a portion of it as under the Halsey plan. Mr. Taylor's plan differs from the Halsey or any of the preceding plans in that it seeks to determine definitely just how much a good man should do and to set the standard so that only good men can attain the higher piece rate level, but liberally rewarding those that can. It also penalizes the poorer worker in greater degree than is done in straight piece work, since the lower piece rate is purposely set very low to spur the man to try to attain the higher rate. The day wage is not assured to the worker under this plan.

To make an approximate comparison with other methods suppose that analysis shows that with improved facilities thirty bolts per day may be taken as a fair day's work. Suppose also that an upper rate of fifteen cents per bolt is sufficient incentive

to the workman to meet this standard, and let ten cents be taken as the lower rate. It will be fair to assume that the machine rate will be increased to say $2.50 because of the more expensive planning department necessary. Then the costs and earnings under this system will be as shown in Table 7 following:

TABLE 7.—EARNINGS AND COSTS UNDER TAYLOR DIFFERENTIAL PIECE-RATE.

No. of bolts.	Material cost.	Day wage.	Piece rate.	Workman's daily earnings.	Machine rate.	Total shop cost.	Cost per bolt.
10	1.00	Not assured	10	1.00	2.50	4.50	0.45
15	1.50	" "	10	1.50	2.50	5.50	$0.36\frac{2}{3}$
20	2.00	" "	10	2.00	2.50	6.50	$0.32\frac{1}{2}$
30	3.00	" "	15	4.50	2.50	10.00	$0.33\frac{1}{3}$
40	4.00	" "	15	6.00	2.50	12.50	$0.31\frac{1}{4}$
50	5.00	" "	15	7.50	2.50	15.00	0.30

107. Advantages and Criticisms. The Taylor differential piece-rate recognizes very fully that low wages do not mean cheap product. Thus, in the above example, the cost at twenty bolts per day is as great as at forty bolts per day. It is evident, however, that in order to reduce the price and at the same time pay a high-piece rate a large quantity must be produced. Thus the cost per bolt at a production of thirty per day is slightly less under the $33\frac{1}{3}$ per cent Halsey plan than under the Taylor system with the data [1] taken. However, under Taylor's method of expert analysis, prediction and preparation the good workman has more chance of reaching this high output than under the Halsey plan that depends on the initiative of the workman alone. The Taylor plan aims to determine just what the maximum product should be under best conditions, leaving nothing to the worker's initiative, but paying him a good rate to insure his coöperation. The criticism usually made of the Taylor system is that it takes away the workman's initiative and tends to make an automaton of him. While this may seem to be the immediate effect upon

[1] The data selected for the several tables are what might well be expected in practice. Accurate comparison of the systems cannot, however, be drawn from these data as the basic rates may be varied so widely.

skilled workmen the ultimate effect of this method would be no different from that of the introduction of any labor-saving device or any division of mental labor from manual labor. All such influences tend to subdivide and reclassify labor, putting the planning into the hands of the more able and the actual execution into the hands of the less able. The Taylor system is a very able analysis of the theory of division of labor, both mental and manual. To what extent it may come into use will depend on grounds other than those already considered.

It is objected also that the method, by measuring accurately a man's capacity for work, puts into the hands of the employer an enormous power that he hitherto has not possessed. This also is true, but is no argument against such accurate measurement. There is no reason why an employer should not know just what value he is purchasing in labor as he does in buying material. He must not, however, be allowed to use this power unjustly. Clearly, rates could be set by this method that would exclude all but the very best men from participating in industry, and because of the increased product the market demand could be filled. It is questionable, to say the least, whether it is better to have production concentrated in the hands of a few or to have every man producing as efficiently as he can and being paid accordingly.

The Gantt Bonus Plan.

108. General Features. It is evident that the differential piece-rate is a difficult one, in general, to introduce because of the fear on the part of the workman that he cannot attain the higher rate and is, therefore, condemned to a lower wage and ultimate dismissal. Mr. H. L. Gantt,[1] a former associate of Mr. Taylor, has devised a plan that obviates this difficulty and yet holds out the reward of good performance. Like Taylor, Gantt makes a very careful study of the work and conditions, and determines just what a good standard performance should be under the best conditions that he can establish. On the basis of these observa-

[1] See Trans. A.S.M.E., Vol. 23, 1902, p. 341; also Work Wages and Profits, by H. L. Gantt.

tions a definite **task** for a given time is set, and if the worker can accomplish this task he receives a **bonus** in the form of an extra time allowance, usually from 25 to 50 per cent of the time allowed for the task; hence the name **task and bonus** which is associated with this plan.

If the workman fails to accomplish the task he receives only his day rate, which is guaranteed to him. The plan, therefore, has the good features of the Halsey plan in insuring the day rate, and hence makes it easy of introduction, and embodies, also, the good features of the Taylor plan in that it makes a high rate of production possible and offers a great inducement for high performance.

To illustrate, suppose that as in the previous example of the Taylor method, the standard performance is thirty bolts daily, and that the day rate is \$3.00 as before. Suppose, also, that the bonus is $33\frac{1}{3}$ per cent of the time allowed. Then the time allowed for *one* bolt is, therefore .333 hours. If the workman makes just thirty bolts per day he earns a bonus and is given credit for $(10 + \frac{10}{3}) = 13.33$ hours, which at thirty cents per hour is \$4.00 per day. If he does not make the thirty bolts he does not earn a bonus and his pay is at the day rate of \$3.00. If, on the other hand, he should exceed the task and make forty bolts he would be given the time allowed for forty bolts plus a premium of one-third that time. Thus, the time allowed for forty bolts is $.333 \times 40 = 13.33$ hours, the premium would be $\frac{13.33}{3} = 4.44$ hours and the worker's daily earnings would be $(13.33 + 4.44) \times .30 = \$5.33$. Table 8 shows the earnings and costs under the Gantt bonus system for the same data as has been assumed for the previous examples.

A study of columns one and five will show that this system gives day pay when the bonus is not earned and piece work pay when the bonus is earned. In the example given, for instance, the day pay is \$3.00 and the piece rate is 13.3 cents.

109. Advantages and Disadvantages. As before noted this plan is easy to introduce and it is humane in its operation. Under Mr. Gantt's methods special attention is given to the training

TABLE 8. — EARNINGS AND COSTS UNDER THE GANTT BONUS PLAN.

No. of bolts.	Material cost.	Day wage.	Bonus.	Workman's daily earnings.	Machine rate.	Total shop cost.	Cost per bolt.
10	1.00	3.00	0	3.00	2.50	6.50	0.65
15	1.50	3.00	0	3.00	2.50	7.00	$0.46\frac{2}{3}$
20	2.00	3.00	0	3.00	2.50	7.50	$0.37\frac{1}{2}$
30	3.00	3.00	1.00	4.00	2.50	9.50	$0.31\frac{2}{3}$
40	4.00	3.00	1.33	5.33	2.50	11.83	$0.29\frac{1}{2}$
50	5.00	3.00	1.66	6.66	2.50	14.16	$0.28\frac{1}{3}$

of the workmen, both in the skill necessary to earn the bonus and also in habits of industry.[1] A careful study is made of all the conditions, all obstacles are removed and every assistance is given to the worker that may help him to earn the bonus. The task must necessarily be set high since the output must be large to greatly reduce the unit cost, and since the bonus is large and the workman gets all the apparent gain. A further incentive to production is provided by giving a bonus to the foreman when a given proportion of men under him earn their bonus. This encourages the foreman, not only to teach the men all he can, but to keep all obstacles from before them. The system has undoubted merit, and under Mr. Gantt's direction it has been very successful in many plants. It does, however, like the Taylor plan, divide the workers into two classes, those that can earn a bonus and those that cannot, and this feature has been criticised. It is questionable, however, if this effect is any greater than the necessary difference in wages that must always exist where men are paid on merit.

The Emerson Efficiency Plan.

110. General Features. The Emerson[2] efficiency plan, while aiming to attain the same results as the systems already discussed, proceeds on a principle somewhat different from any of

[1] See Work Wages and Profits, p. 115.

[2] See Efficiency, by Harrington Emerson.

them, though some features of the plan are similar to some features of these other methods. Like the Halsey and Gantt systems, Emerson assures the workman his day wage. Like Taylor and Gantt, he makes a careful study of the details of production and establishes a standard performance that represents a full and fair task for the worker. For the attainment of this standard a large bonus is offered, as in the Gantt method, but smaller bonuses may be earned before reaching this standard, thus agreeing in a way with the Halsey plan.

To make this method clear suppose that a job is standardized at 120 hours. If the workman performs the task in 120 hours his efficiency is said to be 100 per cent. If he takes 240 hours his efficiency is 50 per cent. If he takes only 100 hours his efficiency is 120 per cent and so on. No bonus is paid the worker unless his efficiency reaches $66\frac{2}{3}$ per cent, but he receives only his day pay. At this point he receives a very small bonus, but the bonus increases as his performance rises till at 100 per cent efficiency he receives 20 per cent of his day wage as a bonus. For greater performance greater bonuses are paid till at 140 per cent efficiency the worker receives 60 per cent of his wages as a bonus. The bonus rates for the several efficiencies are given below in Table 9, from which it will be seen that the bonus for the lower efficiencies is very small but increases rapidly as the efficiency rises.

TABLE 9. — EMERSON BONUS RATES.

Efficiency per cent.	Bonus per $1.00 wages.	Efficiency per cent.	Bonus per $1.00 wages.	Efficiency per cent.	Bonus per $1.00 wages.	Efficiency per cent.	Bonus per $1.00 wages.
67	0.0001	78	0.0238	88	0.0832	99	0.1881
68	0.0004	79	0.0280	89	0.0911	100	0.20
69	0.0011	80	0.0327	90	0.0991	101	0.21
70	0.0022	81	0.0378	91	0.1074	102	0.22
71	0.0037	82	0.0433	92	0.1162	103	0.23
72	0.0055	83	0.0492	93	0.1256	105	0.25
73	0.0076	84	0.0553	94	0.1352	110	0.30
74	0.0102	85	0.0617	95	0.1453	120	0.40
75	0.0131	86	0.0684	96	0.1557	130	0.50
76	0.0164	87	0.0756	97	0.1662	135	0.55
77	0.0199	87.5	0.0794	98	0.1770	140	0.60

In the practical operation of this method by Mr. Emerson the bonus is calculated monthly and not for individual jobs. Thus, if a man's wages are $0.30 per hour, and if during a given month he has worked 240 hours, doing in that time jobs whose total standard times have been set at 210 hours, his efficiency is $\frac{210}{240} =$ 87.5. His wages are $72, his bonus (see table) is 7.94 per cent of his wages, or $5.72, and his earnings $77.72. The advantage of this monthly award is that it tends to make the worker desirous of making a bonus on *every* job since the averaging in of a number of poor performances with a few good ones would, in all probability, mean the loss of any bonus that he may have earned on these good performances.

To make an approximate comparison with the other systems let the standard performances as before be 30 bolts and the day wage $3.00; then the earnings and costs under the Emerson plan are as given in Table 10.

TABLE 10. — EARNINGS AND COSTS UNDER EMERSON PLAN.

No. of bolts.	Material cost.	Day wage.	Efficiency per cent.	Bonus.	Workman's daily earnings.	Machine rate.	Total shop cost.	Cost per bolt.
10	1.00	3.00	0.33⅓	0	3.00	2.50	6.50	0.65
15	1.50	3.00	0.50	0	3.00	2.50	7.00	0.46⅔
20	2.00	3.00	0.66⅔	0.03	3.03	2.50	7.53	0.37½
30	3.00	3.00	100	0.60	3.60	2.50	9.10	0.30⅓
40	4.00	3.00	133⅓	1.59	4.59	2.50	11.09	0.27¾

As in all bonus systems where the workman receives a large part of the apparent gain, the output must be large in order to reduce the cost, and as a consequence, the standard performance must be set so high that only the best men can attain it. The system is, therefore, selective in its operation though not so markedly so as the Gantt and Taylor systems since there is some provision made for all men that can attain an efficiency of 66⅔ per cent.

Résumé.

111. It is difficult, if not impossible, to draw accurate comparisons between the several methods of payment discussed in the preceding articles because of the different foundations on which they rest and the widely differing practice they lead to; and the tabulated figures given for each method must, therefore, be taken as suggestive rather than conclusive. They do, however, make it possible to compare these systems so as to show clearly the relative importance they may possess in the eyes of the employer and the employee. In making this comparison it must be remembered that the interests of these two classes of men are not always the same. The employer naturally buys labor as cheaply as he can, the worker naturally sells his labor at as high a price as he can command. The employer wishes large output; the worker is in general not interested in increasing his output *unless his compensation increases accordingly.* Mr. Taylor says [1] that in order to induce men to put forth their best efforts it is necessary to pay laborers from 30 to 60 per cent more than the average of their class; ordinary mechanics from 70 to 80 per cent more than the average of their class; and for work requiring skill, brains, close application and bodily exertions, as high as 100 per cent extra compensation is needed. This statement is, in general, undoubtedly true. The fact that increased output eventually benefits not only the employer but also the employee has little or no influence on the worker. He is not willing, and justly, to forego present profits for the sake of prospective gains that are, after all, somewhat problematic and uncertain. Hence he wishes as high a wage as he can obtain regardless of output; in fact, he is inclined to look upon increased output with distrust as leading to a full market with a resulting drop in labor values.

The employer also desires low unit costs. If he can obtain this and also obtain great output his position is very favorable. However, there is a great advantage in large output even if the shop costs do not materially change; since the greater his output

[1] Trans. A.S.M.E., Vol. 24, 1903, p. 1346.

per dollar of investment the greater is his percentage of profit for a given gain per piece sold. Clearly, it is more profitable to sell one thousand pieces per month than to sell only one, the gain per piece being the same in both cases. A wage system, therefore, that will stimulate output even though it does not materially reduce the unit cost, is a desirable matter.

In comparing these new wage systems with day work it would seem fair to consider day work at its best and not to compare them to day work where the worker is producing a small fraction of what he is capable of. Such conditions, are, perhaps, too common, but they are due more to defects in management than in the principle of day work. It would not seem to be unfair to consider that the worker on day pay is producing three-fifths of what he is capable of under the existing conditions. Hence, in the illustration cited (Art. 100) where fifteen bolts are produced daily, twenty bolts may be taken as a maximum performance under the existing conditions and surroundings, provided the worker receives a financial stimulus sufficient to insure his maximum effort, or such as he can put forth continually without injury to himself.

In Fig. 16 the line *ACK* represents the worker's hourly pay for any hourly output whatever at 30 cents per hour; one and one-half per hour or fifteen bolts daily being considered a good day's work. If now the worker is put on piece work at a rate equivalent to his day work performance, or 20 cents per bolt, his earnings will be represented by the line *OB*, and when he reaches the maximum attainable performance of twenty bolts per day or two per hour his hourly rate rises to 40 cents. (If he has been working far below his capacity his output may rise very high, indeed, comparatively, but if it does so rise the inevitable cut in rate quickly follows.) Should he fail to produce fifteen bolts, his decreased earnings would be represented by *OC*.

Since the Halsey system and all its modifications, as illustrated by the Rowan plan, are not based on changes in surrounding conditions or facilities, it would not be expected that they could stimulate the output beyond that attainable by piece work. The advantage of this system is that it insures the workman his

day rate and under these methods his curves of earnings are *ACPG* and *ACDH* respectively, and both of these curves lie below the piece work curve, hence the remuneration per piece is less by these methods than by the piece work plan. They are,

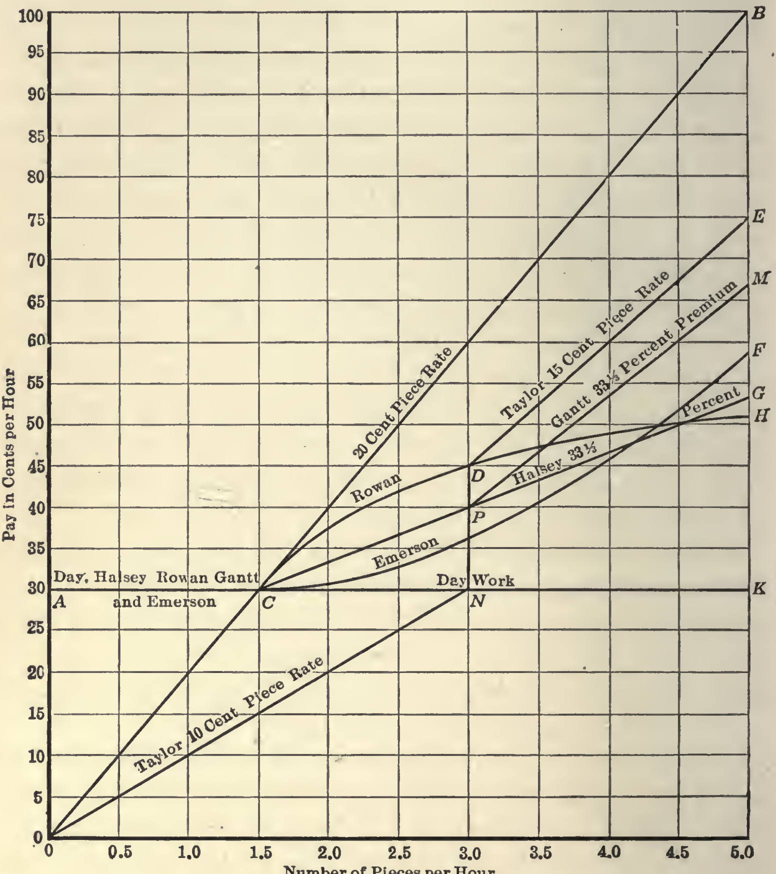

FIG. 16.

however, much more likely to secure the maximum product of twenty pieces since they insure the day rate and workmen may look upon them with less distrust.

The Taylor, Gantt and Emerson methods proceed on the general principle that not only does increased compensation stimu-

late the output but that still greater gains can be made by making the conditions surrounding the workman the very best and by instructing him in the very best method of procedure. It has been assumed in this case that these methods will increase the output 100 per cent or to thirty bolts daily. Then the pay of the worker under these several methods is fairly well represented by the lines *ONDE*, *ACNPM* and *ACF*, respectively. It is assumed that the piece rate under the Gantt system may be somewhat lower than under the Taylor system in order to produce the same incentive, since the Taylor plan does not insure day's pay. The lines *OC* and *ON* measure rates of pay below the standard wage of 30 cents, but the Halsey, Rowan, Gantt and Emerson curves and that part of the Taylor curve that measures earnings above 30 cents per hour lay between the straight piece work curve *CB* and the day rate curve *CK*. That is, the reward of the worker is, in general, greater on piece work and less on day work than by any of the other pay systems for all outputs above the standard rate of fifteen pieces per day. This is necessarily so in the Halsey and Rowan plans from their very nature. It is true of the other plans because the great increase in output under these new methods is due only in part to increased remuneration (the effect of which has already been shown to have limitations) and in greater part to the extended division of labor under these methods and the assistance given the worker. The latter is, therefore, not entitled to a proportionate reward as in straight piece work and if he were it could not be paid without increasing the unit costs above piece work costs since the planning of the work and the training of the workmen under the new systems are items of expense that must be included in the costs. It is clear, however, that these more advanced methods of rewarding labor are effective in raising the output and at the same time paying higher wages than could be paid under ordinary day or piece work, at the same time keeping the costs as low, if not lower, than when the increased output is obtained by financial stimulation alone.

It is obvious that the cost per bolt for a large output will be less under day work than under any of these methods that pay

higher rates for higher output, and it is also clear that the unit cost will be less under the Halsey plan and its modifications than under piece rates, since the worker receives a portion only of the gain accruing from his increased activity. The effect of the Taylor, Gantt and Emerson systems on unit cost is not so clear, and the assumption so often made that increased output necessarily means decreased unit cost is not warranted except when other factors remain constant. The increased output under these methods is due as before stated to the incentive of high wages and to a detailed planning of the work accompanied by expert advice to the worker. The cost of this last feature may make a large addition to the shop burden and, therefore, the unit wage cost is not a correct measure of the total unit cost. In the examples cited it was assumed that an increase of 100 per cent in output could be obtained by these advanced methods with an increase in the machine rate of 25 per cent, which would seem to be conservative. To make comparison easier the unit costs under each method (*i.e.*, the last column in each of the foregoing tables of cost and earnings) are tabulated in Table 11.

TABLE 11. — COMPARISON OF COSTS UNDER VARIOUS SYSTEMS.

Number per day.	Cost per bolt in cents.					
	10	15	20	30	40	50
Day work	60	**43⅓**	35	26⅔	22½	20
Piece work	50	43⅓	**40**	36⅔	35	34
Halsey premium	60	43⅓	**36⅔**	30	26⅔	24⅔
Rowan premium	60	43⅓	**38¾**	31⅔	27⅕	24⅕
Taylor piece	45	36⅔	32½	**33⅓**	31¼	30
Gantt bonus	65	46⅔	37½	**31⅔**	29½	28⅓
Emerson efficiency	65	46⅔	38	**30⅓**	27¾	......

The black faced figures in the table denote the costs for the highest probable output under each system. It will be noted that in each case the cost for day work is lower, and for piece work higher than for any other system except in the smaller outputs where some of the advanced systems naturally give

higher costs because of increased shop burden. But it is evident that if the remuneration or the added shop burden in the Gantt, Taylor or Emerson systems should be much more than what has been allowed, the reduction in cost over simpler systems would be problematic. However, it should again be noted that even when there is no reduction in cost the gain in output is highly important and desirable.

As previously stated these mathematical statements must be taken as approximate and as indicating general principles only. They are such, however, as might occur and may, therefore, assist in visualizing the relations that exist between these much discussed methods. Of course each shop is a problem by itself and a method that may be satisfactory in one may not work at all in another. It is also obvious that an infinite number of pay systems can be devised along the lines of the advanced methods discussed. The importance of these new methods does not lie so much in the fact that they assist in securing greater output at lower cost and higher wages, as in the *tendencies* that they portend. It really does not matter very much what pay system is used so long as it is just to employer and employee, insuring to the one full value for his money, and rewarding the other fully for his effort.

There are, however, two very important features involved in these new methods that deserve more than passing thought. Under the older system of day work it is necessary in most cases to *drive* the worker in order to obtain his best efforts. Under piece work this is not necessary, but the worker has to take chances against losses sometimes beyond his control, and this he is not inclined to do and often cannot afford. The newer methods frankly recognize that men must be paid for extra exertion, and this is a step in the right direction away from slave-driving methods.

The other feature is even more important. Under day work, piece work, and to a large extent under the Halsey plan, the conditions of production are not changed where added incentive is given to production. Under the Taylor, Gantt and Emerson methods radical changes are involved, affecting not

only the equipment but the workman himself. The introduction of the planning department, functional foremanship and other features of advanced management so closely connected with these modern pay systems, portend a much further application of division of labor than heretofore contemplated. The effect of these changes on the workman will be marked, as these influences tend to disintegrate still further the trades and to reclassify workers into new groups. Mr. Taylor[1] expressed this idea very clearly when he said — "The full possibilities of functional foremanship, however, will not have been fully realized until almost all of the machines in the shop are run by men who are of smaller calibre and attainments and who are, therefore, cheaper than those required under the old system." The new wage systems are, therefore, closely tied up with radical changes in management and are, in a way, not comparable with old methods in their ultimate effect on the workman.

Furthermore, the new methods approach the problem of remuneration from a new view point. Labor is measured exactly, all obstacles are removed as far as possible, and the worker is expected to reach a predetermined performance in exactly the same way in which a scientific farmer determines the efficiency of a cow or the output of a hen. This, in itself, is not of importance; *but if these methods are to be used as a means of eliminating all that fall below a given standard* it opens up a grave and perplexing problem. In the case of the farmer it is an easy problem; in the case of men and women it is not so easy.

It will be seen, then, that modern wage systems are closely interlocked with systems of *management*, and back of this again, often forgotten, but never absent, awaits the greater problem of humanity and human existence. The time was when wages were settled without much regard to this greater problem, but unless all signs are misleading it will soon be the great factor in both industrial management and reward. A future chapter will discuss more fully the limitations of some of these new methods (see Chapter 14).

[1] See Tran. A.S.M.E., Vol. 24, page 1295.

Profit-Sharing Methods.

112. The student of industrial problems turns naturally to a consideration of coöperative methods as a means of restoring, in a measure, what the workman has lost by separation from the tools of production; and many comprehensive attempts have been made to realize some of the benefits of coöperation in actual practice. A few have met with some measure of success, where the conditions were favorable, but the great majority have been failures.

One of the most common forms of this idea is the profit-sharing scheme whereby a certain percentage of the profits are distributed at fixed intervals, usually annually or semi-annually, in some definite ratio to all employees that have been in the employ of the firm for a stated term. The difference between this plan and the wage systems discussed should be clearly noted. Under all of these wage systems the extra reward is *individual*, is based on diligence and skill, and is paid at once. Under profit-sharing the bonus comes at long intervals and as a result of many conditions that are obscure and conflicting to the worker. Furthermore, the conditions that fix the possibility of such reward are, to a large extent, not under the control of the worker and any extra effort he may make may be more than offset by foolish mistakes in management or unfortunate trade conditions. The reward is too remote to interest him to the same extent as the pay systems discussed. This method of bonus award also makes no distinction between the diligent and lazy, which is manifestly unfair, and incidentally one of the basic troubles that lie at the root of all coöperative schemes. Clearly, such unjust discrimination must tend to kill personal incentive and ambition and to reduce all efforts to mediocrity. Any system that eliminates personal ambition and individual incentive is foreordained to failure.

The same remarks apply, in a general way, to schemes which permit employees to invest in shares of the company's stock on advantageous terms. As a means of bettering the financial status of the employee and of obtaining his interest, they no

doubt are valuable; but they should not in any case be looked on as rewards for increased diligence. As Mr. Going has well said — "There is no necessary automatic and manifestly just relation between an employee's efficiency or faithfulness and his ability to save money and invest in stocks. The most deserving man in the company's service may have a large family, or a sick wife, or dependent parents, and he may have to turn aside from the opportunity to become an investor and see it go to someone whom he knows (as perhaps only one workman can know another) is less worthy." What he needs and desires is immediate and proportionate reward for his labor.

There are other difficulties in the path of profit-sharing schemes. Workmen are always willing to share the profits but are neither willing, nor as a rule able, to share the losses. Nor is there any just reason why they should participate in the losses since these are matters, in a way, beyond their control. Any division of profits will, in general, be looked upon as a gratuity and not as a reward for extra effort or diligence. While, therefore, profit-sharing is most praiseworthy and to be commended, it should not be confused with the more vital problem of the immediate reward of labor according to its deserts.

References:

Shop Management, by F. W. Taylor, Trans. A.S.M.E., Vol. 24.
Work Wages and Profits, by H. L. Gantt.
Efficiency, by Harrington Emerson.

CHAPTER XII.

PURCHASING, STORING AND INSPECTION OF MATERIALS.

113. Sources of Supply. Viewed broadly, all industrial effort is concerned with the transforming of natural resources into useful forms and the transportation of the same to the places where they are needed. As each increment of labor is bestowed upon the material, as it passes through the process, it rises in value. Thus, coal is mined in one place, iron ore in another. Both are transported to some convenient place, arriving there worth a few cents per hundred pounds. By means of the coal the iron is here transformed into pig iron worth perhaps one cent per pound. This pig iron may be transformed in the same plant into steel rails worth $1\frac{1}{4}$ cents per pound, or it may be again transported to some engine works and made into steam engines worth 20 cents per pound. Or it may be shipped to a crucible steel works and made into crucible steel bars worth 16 cents per pound and these steel bars may be transformed elsewhere into watch-springs worth many dollars per pound. This is true, in a general sense, of all the products of industry; material values being, in the main, accumulated labor values, the value of the original material in its natural state being, often, a negligible part of the market value.

In some cases the transformation of the raw product into useful form is accomplished in one plant. Thus, table salt, kerosene and similar commodities may each be made in a single reduction works and placed directly upon the market. In most cases, however, this is not so, most market products being the result of several distinct stages of manufacture, each stage separated widely by character and geographical distance. This is so from the nature of the case and from the complexity of modern manufacturing. The man that smelts pig iron would not be expected to produce, also, all the finished products into which it

enters; in fact, he may be compelled to supply a widely diversified field of industry in order to secure the quantity necessary to manufacture pig iron economically. These general conditions apply to all those that in turn transform pig iron into other forms, and equally again to those that in turn use these other forms for other purposes.

What, then, appears to one manufacturer as *finished product* appears to some other manufacturer as *raw material,* and the extent to which any manufacturer may depend upon other branches of industry varies widely. In very few instances is he entirely independent of other lines of industry.

As pointed out in Article 64 the materials that enter into any given finished product are, in general, of two kinds, direct and indirect; and even though a manufacturer may control the direct material from its natural sources to the market, he must, in most instances, depend on other people for much of his indirect supplies and his tools of production. If, however, the required quantity of any material, direct or indirect, becomes great enough it may pay the manufacturer to extend his control of that particular material a little farther back toward the natural sources. Thus, a growing concern may not have enough demand for castings to operate a foundry, but as the business increases it may pay to build one, even though no reduction in price is so obtained, in order to control the supply of castings and thus facilitate deliveries. If the quantity increases so that foundry work can be prosecuted as economically as in the foundries from which castings were formerly purchased, the profit formerly paid these foundries is thereby saved (see Art. 22). The electrical manufacturing companies in this country depended originally on other sources for their porcelain and mica products and small companies still do so. As the quantities incident to great growth have appeared, some of the larger electrical works have put up their own porcelain works and have installed presses for making mica products. Some have even put in wire-drawing plants, not so much with a view, perhaps, of obtaining lower priced wire, as for convenience and better control of deliveries. The importance, therefore, of the control

of the several streams of material coming into an industrial plant will depend on their relative bearing on questions of economy of manufacture or convenience as affecting delivery of finished goods. It may be highly important to control a large stream for financial reasons. It may be no less important to control a very small one because of its effect on deliveries. The lack of a small detail will hold up the delivery of a machine as effectually as will a larger one; and thus control of the sources of supply may vary from the simple case where all materials are fully controlled, to the other extreme where nothing but *assembling* is carried on, the finished parts coming from many factories ready to be assembled. The first extreme is rare but many cases of the latter are to be found.

114. Purchasing. The relative value of the labor and material that enters into any product will, of course, vary greatly with the industry considered. In some cases the material cost may be negligible, as compared with labor, and again it may be much more important than labor; but in all industries the purchasing of materials and supplies should be very carefully considered and properly provided for. Responsibility for all purchases should be centralized, and purchasing by several persons should never be tolerated as it always leads to loose, extravagant ideas and methods, higher purchase prices and needless waste. The opportunity for dishonesty is also much increased. A good purchasing agent is always a valuable man and as the size and complexity of a business increases, his value rises.[1] It is axiomatic that he must possess the business training and natural commercial instinct that will make him a keen student of market conditions and a judge of values. It is equally important that he be able to systematize his department so that it runs smoothly in connection with the other departments *serving* them quickly and well. If, in addition, he is well informed on the technical and practical side of the industry his efficiency will be increased many fold. For these reasons a man promoted from the shop or engineering department, all other things being equal, will

[1] The purchasing department of a large manufacturing plant will be very large and carefully divided into sub-departments. (See Art. 43.)

make a better purchasing agent than one promoted from the clerical force of the office. Purchasing, however, involves a knowledge of business methods and forms, of which shop men and engineers are, unfortunately, seldom well informed; hence, purchasing agents are usually recruited from the clerical force.

The demand for materials grows naturally out of the needs of the business and cannot, therefore, originate with the purchasing agent. In a shop devoted to general repairs, the requisitions for materials would, most naturally, originate with the foremen in charge of work since they will know better than anyone what is wanted. In a shop building new work to order only, such as an engine works, these material requisitions for direct material would originate in the engineering department, though they might pass through the storekeeper's hands before going to the purchasing agent in order to check off material on hand. In a shop manufacturing standardized articles, as knives, watches, etc., the material requisition would naturally originate in the stores department, which is the reservoir that feeds the factory and here also would originate, always, the requisitions for all indirect and expense material. In a shop doing all three of these classes of production, therefore, material requisitions might originate from several sources; and just as it is necessary to centralize the authority and responsibility of the purchases based on these material requisitions, so it is absolutely necessary to fix definitely the authority and responsibility of originating these requisitions. In a factory that is well managed this power is limited to responsible men, and the requisitions in many cases must be countersigned by some higher official as a check on irregularities. The making of requisitions, the purchasing of materials and the clerical machinery involved is simplified and expedited by the use of printed forms[1] and blanks, a discussion of which is beyond the limits of this treatise.

Skillful purchasing involves five principal features, namely:

(*a*) **Price.**

(*b*) **Quality.**

(*c*) **Quantity.**

[1] See Factory Organization, by Hugo Diemer.

(*d*) **Time of delivery.**

(*e*) **Verification of goods purchased.**

(*a*) For a given quality and quantity of material the securing of low prices becomes a commercial matter depending on a knowledge of the sources of supply, transportation facilities, market conditions, discounts and similar considerations that apply to all purchasing. Price, however, is not always the only factor that must be considered, for as will be seen, an effort to obtain low purchase prices may result in high manufacturing costs, though it is fundamental that, other things being equal, the lowest possible prices should be obtained.

(*b*) It is obvious that the judgment of the purchasing agent as regards the quality of materials required increases with his knowledge of the trades and processes for which he buys. In the buying of many indirect or expense materials such as oil, waste, stationery, etc., it is customary in many plants to trust to the judgment of the purchasing agent. In fact, this is true in many cases of much of the direct material. But as an industry grows more complex and the scientific knowledge on which it is based becomes more important, the purchasing agent must depend more on the expert in each line for instructions as to the quality of material required. In electrical construction the quality of many materials is of highest importance and the characteristics must be carefully specified to the purchasing agent. Many large companies keep well-equipped experimental laboratories for determining the best qualities of material; foundries now buy their iron by chemical specification; and careful managers specify the character of their supplies, such as coal and oil. Best results will, therefore, be obtained when the special buying ability of the purchasing agent is reinforced by the expert knowledge of the specialist who knows the characteristics desirable in the material under consideration.

(*c*) The temptation to buy large quantities of material is always strong for two reasons. First, lower prices are obtained as the quantity to be purchased increases, and second, a large stock on hand insures prompt service to the shop and consequent quick deliveries. But here again the judgment of the purchas-

ing agent should be reinforced by expert knowledge and advice. Clearly, there is no money in ordering several years' supply of any one article, storing it, and thus tying up considerable capital and losing the interest thereon simply for a small saving in price. The quantity ordered, therefore, should have a reasonable relation to the prospective output of the factory. Furthermore, before placing orders for large quantities of stock, particularly special stock, careful inquiry should be made as to prospective changes in design that may render such stock obsolete; an occurrence only too frequent in an industry that is in a state of development. In large works a great purchasing advantage can be obtained by standardizing, as far as possible, articles of a similar character used by different departments, thus decreasing the variety and increasing the number of each kind purchased. This principle should be observed from office lead pencils to the largest common supplies and tools purchased.

(*d*) The time element is a most important one in purchasing. It is essential that all material for a job arrives so as to be fabricated in time to avoid delay in assembling the completed product. Yet a contract might be taken for machines involving the use of tons of copper, say, and requiring a year for completion, the copper not being needed till near the end of the construction. Evidently the purchasing agent working in connection with a good planning department can save considerable money by means of well-arranged schedules of delivery. The same thing can be accomplished for material used constantly, such as coal, by making long-term contracts but with periodic deliveries and payments. In other cases, again, the purchasing agent is often justified in paying a high price for a quick delivery if it will save great delay in the factory or secure a remunerative contract because of early shipment.

(*e*) The verification of purchased goods is usually conducted by the receiving department which is, in general, a branch of the stores department and is therefore discussed among the problems of that department. (See Article 118.)

Stores and Stock.

115. Functions of Stores and Stock. Under ideal manufacturing conditions the raw materials would be used as fast as they arrived at the factory, passing directly through it; and the finished product would be shipped to customers as fast as it was turned out. Such conditions are almost impossible to attain, though it may be approached in some of the simple continuous industries. In most manufacturing industries the raw materials are used in varying amounts at varying times, and sales are likewise intermittent and varied. For these reasons, and also because purchasing and transportation are facilitated by quantity, provision must be made for storing such quantities of raw material as will insure prompt service for these varying demands. Where sales are varying and product must be made in advance of sales similar provision must be made for caring for finished product, in order to insure prompt delivery to customers. In shops that make product to order only, as a shipbuilding company, this last feature would not be important.

Unworked material is usually known as **stores** and the space where it is housed is known as the **store-room.** The store-room is in effect a reservoir between the incoming materials and supplies and the factory proper, equalizing the varying supply and demand. Finished product ready for shipment is usually called **stock** and the place where it is stored is called a **stock-room.** The stock-room is in effect a reservoir between the factory and the selling department equalizing the varying demand of the customer and the varying output of the shop. In small factories the store-room and stock-room may be one, and under the control of the same official but there is a distinct difference in their functions, and as plants grow in size separation becomes almost inevitable.

In order to obtain the advantages of manufacturing a large number of pieces of one kind it is often necessary to finish large numbers of parts of machines or other products and store them, drawing them out for final assembly in completed products as the business of the factory requires. In fact, in some factories

carrying on semi-continuous manufacturing, the quantities are so large that it is necessary to store them between successive operations, especially if the materials involved are valuable. In many cases, also, the same part is used in several different kinds or sizes of product that come through the factory at different times and repairs and supply parts always demand a stock of standard finished parts on hand. The store-room may, therefore, also act as a reservoir to equalize inequalities in the manufacturing processes of the factory by storing so-called **finished parts** and in some cases a special section of the store-room called the **finished-parts store-room** is set aside especially for this purpose. A distinction is sometimes made between finished parts made by the factory and those purchased. Thus bolts, screws or any other element that is purchased and used directly in the product are, strictly speaking, finished parts and are sometimes called **purchased finished parts** to distinguish them from **manufactured finished parts.** The distinction is, however, somewhat academic and not of practical importance provided the cost of each article is accurately determined. The store-room may be said, therefore, to care for three classes of material:

(*a*) **Stores,** or raw material that is to be fabricated into product, consisting largely, therefore, of direct material.

(*b*) **Supplies,** or indirect material, such as oil, waste, etc.

(*c*) **Finished parts,** or product, fabricated, but not fully assembled.

The stock-room in its fully developed form will care only for finished product, that is, fully fabricated and ready to be shipped. In large organizations this department comes, naturally, under the shipping clerk. In such cases the stock-room may carry many finished parts for convenience in supplying repair parts. In smaller concerns the stock-room, store-room, shipping and receiving rooms may be under one man and in one room. But as factories grow in size these different functions should be separated in the interests of efficiency.

116. Store-room Methods. The necessity and the advantages of a well-organized store-room are not always fully recognized. Managers who would look with horror upon a financial system

that would permit the easy extraction of small sums of money from the office safe, often look complacently upon store-room methods that permit the unauthorized withdrawal of valuable material from the stores, wastes due to excess material drawn, and losses due to valuable material unaccounted for, out of all proportion to their care of the cash in the office till. Managers who would look most carefully into the tying up of money in securities permit the investment of large sums in raw material with little thought as to the relative amount invested, the possibility of how long it may remain so tied up, or the depreciation it may suffer while so invested. Yet material represents value as truly as the money in the office safe, though this is not always appreciated. Any saving in material is as effective as a saving on the pay roll. Money tied up in material is *crystallized* capital and while in this form is inactive. Clearly, the amount so invested should be carefully scrutinized and its total kept as low as proper service of the factory will allow.

The principal business of the store-room is to anticipate the needs of the factory in the most effective and economical manner possible. In order to accomplish this it must fulfill the following functions perfectly:

(*a*) Issue requisitions on the purchasing department for the most economical amount of the right kind of material for delivery at the most advantageous time.

(*b*) Check all material received as to quality and quantity.

(*c*) Store all material in a safe and convenient manner.

(*d*) Issue materials and supplies in the exact amounts needed and at the exact time required.

(*e*) Maintain exact records of all receipts and issues and of all balances on hand.

The work of the stores department is, therefore, closely connected with that of the purchasing department on the one hand and with the shop and cost system on the other. In small concerns the store-room and purchasing department are included in one department.

Item (a). As noted in Article 114 the origin of requisitions will vary with the character of the industry but, most usually, all

requisitions originating outside the store-room should be passed upon by the storekeeper so as to insure the use of material on hand before ordering more. For this reason all requisitions are drawn on the store-room in some organizations, the store-room alone requisitioning the purchasing department.

The problem presented in obtaining material for repair work or for special work done on order is comparatively simple, since the quantity and quality are here fairly definite in character, the question of *time*, however, being often of great importance. If the work is of great magnitude and is to extend over a considerable period of time a careful planning, either by the engineering department or the planning department, of the time schedule on which materials should be delivered, is almost essential to prevent premature and over-investment of funds. In the case of repairs, on the other hand, quickness of delivery is usually an essential.

The problem of anticipating the needs of a large factory that is manufacturing standardized products of several kinds and many sizes is a much more difficult problem, including as it does the consideration of the quantity of raw material that should be carried in all stages of fabrication from raw material to finished product. An adequate discussion of this problem, which is one of the most important in all manufacturing, is beyond the scope of this book; but a brief outline may be of interest and assistance. Among the leading considerations that must be given weight in deciding what stock of goods shall be carried in the several stages of production the following may be noted:

(1) The demand for the particular part or combinations of parts.

(2) The saving that may be effected by manufacturing in quantity.

(3) The interest on the capital tied up in material in process of manufacture, and in facilities for storing and caring for it.

(4) The time required to obtain raw material and to assemble it into completed product from various stages of fabrication.

(5) The probability of change of design and consequent depreciation of raw material, finished parts or completed product.

To make the interrelation of these considerations clearer consider a hypothetical problem of manufacturing a complete line of alternating-current transformers. The demand for the smaller sizes of transformers or, say, up to 100 kilowatts, is large though varying, very quick deliveries are essential, the voltages are moderate and the design will be assumed to be fairly stable. These small sizes would be in continuous manufacture, or they would, at least, be passed through the factory in large lots, finished completely and put in stock. To facilitate delivery some stock of these sizes would also be carried in branch sales office. Complete sets of special winding machines and other labor-saving devices would be developed so as to take advantage of quantity in reducing shop costs. The anticipating of the demand for raw material for this case is comparatively simple, care being necessary only to see that the supply of any material does not get so low before ordering that production is held up; and care exercised on the other hand that the amount ordered is not so excessive as to tie up too much capital or to run the risk of any of it becoming obsolete through changes in design. This case represents in a general way the problem of continuous processes of all kinds.

Now, in general, the demand for a given class of product lessens as the size of the unit increases. Transformers from 100-kilowatt to say 250-kilowatt capacity would probably not be in such demand as the smaller sizes and would not be carried in branch office stocks.

The demand may also vary with the season.[1] Nevertheless,

[1] Seasonable products are often difficult problems. They must, as a rule, be made during the season when they are not wanted so as to anticipate the market, and production comes to a standstill during the season of demand. Manufacturers usually try to equalize these demands by making articles that are complementary; as, for instance, fan motors may be manufactured during the winter for the summer trade and arc lamps during the summer for the winter trade. Other lines of industry do not permit this principle because of limitations in the equipment.

the yearly demand is such that they can be economically put through the shop in large lots, the size of these lots and the proper times for authorizing their production requiring careful consideration to keep the investment as low as is consistent with prompt delivery. A good equipment of special tools might also be warranted for these sizes though they may not be in continual use.

Transformers of say 500-kilowatt capacity may present a very different problem. Here the demand may be so small that it may not be advisable to put large lots through to completion and stock, because the interest on the money so tied up would more than equal the saving made by production in quantity. Yet the time required to manufacture these larger sizes may be prohibitive from the standpoint of the salesman and therefore it may be good policy to make up and stock some of the parts that require the longest time to produce. Thus the copper coils may be wound and insulated and carried as finished parts, thus also providing spare parts for repairs. A limited amount of sheet steel for building up the laminated cores might also be carried among the finished parts. The cast-iron casings or any steel or malleable-iron castings that require time to obtain might be carried in the raw material supplies, labor being expended only on such parts as would greatly facilitate delivery when orders to assemble these sizes were received. The outfit of special tools for these sizes would also be very limited and carefully considered.

In the case of still larger sizes not even finished parts of any kind would be justifiable and only such raw materials as require a considerable time to obtain would be carried. Thus, certain special sizes of copper strip might be justified though most usually special material of any kind should be avoided, if possible, since, if rendered obsolete for any reason, it depreciates very rapidly, and is, in general, useless for other purposes. No special tools might be justified for these larger sizes because of the small quantity demanded.

In still larger sizes and perhaps for higher voltages it may be that not even raw materials should be carried. The more

difficult engineering problems involved, the possibility of changes in design, the varying requirements to be met in the field, would, perhaps, make all anticipation of materials hazardous and out of the question. The problem has passed from the extreme case of the continuous industry to the other extreme where the product must be made to order and material ordered as needed and not anticipated.

The relative sizes assumed above are of course hypothetical but entirely possible. The principles involved are, however, universal. The question of the quantity and form in which material shall be carried is not a simple one, nor one that can, in the general case, be decided by any one man. The storekeeper can easily handle the extreme cases. In the cases that approach continuous production it is simply a matter of considering the stock bins as hoppers feeding the factory. Minimum limits can be set to each bin, or other storage, that will serve as a warning to order more material. Maximum limits may be set based on the sales demands that will prevent over-investment. In the other extreme where work is done to order, the problem is specific as to quality and quantity and the important element is the time relation. But between these extremes the combinations are complex and an intelligent solution can be reached only by the joint efforts of the storekeeper, the salesman, the engineer, the financier and the toolmaker. (See also Article 49.)

Item (b). The inspection of material as it is received is discussed along with the general problem of inspection in Article 118.

Item (c). It is axiomatic that all materials should be stored in places where they will be safe against deterioration or pilfering. They should also be stored in a convenient and systematic[1] manner and so that they can be delivered quickly to the shop. In large works branch store-rooms are a necessity, both for reasons of convenience and economy. If the stores are extensive a book, plan or written record of some kind showing the location of stores is imperative to guard against the delay and confusion

[1] For a helpful article on stores arrangement, see Engineering Magazine, Nov., 1904.

arising from the loss of experienced employees who carry such matters in their heads. The same remarks apply to pattern and other storage problems. A carefully planned systematic way of storing tools, patterns and materials of all kinds is an important feature of good management.

Item (d). In former times, when shops and factories were small, materials and supplies were stored on open shelves and each workman helped himself to what was wanted. The custom still prevails in small plants, particularly where the stores are such as are of no personal value to the workmen, or where they consist of indirect material and form a very small part of the material cost. There are, no doubt, many cases where it would cost more to employ a storekeeper than he could save by his watchfulness; but in most cases it pays to put all stores under a good storekeeper, give him proper facilities to keep the stores properly, and then hold him responsible for wastes and losses, so far as the stores are concerned.

It is common experience that workmen cannot, in general, be trusted to draw either direct or indirect material from stores without great waste, both as to the quantity drawn and its economical use. Furthermore, loose methods of issuing materials are always likely to lead to dishonesty and pilfering. The first method of checking these difficulties was to put the responsibility on the foreman. Under this system each foreman is furnished with an order book and no article can be issued from the store-room except on the authority of the foreman's order which describes the material required, the amount needed, and the order number to which it is to be charged. Indirect material is ordered in the same way; in many cases the foreman also notes the order number to which the expense material is to be charged, this number usually being the order number on which the workman is, at that time, employed. The unfairness of such a method of distributing expense material is obvious. The orders issued by the foremen are taken up by the storekeeper and are his authority for the issuance of the material and also the basis of material costs.

The advantages of such a system are its simplicity, flexibility

and quickness. No delays are experienced in getting the material from the stores to the factory floor. It responds instantly to emergencies, either in production or in the shop repairs. There are many places where it is adequate, particularly where the force of men is small, the foreman intelligent and the stores of no value to the workman personally, and where the number of orders issued daily is small and the accounting consequently easy.

On the other hand as departments become larger it is not good economy to use a busy foreman for this purpose. His time is more valuable for other purposes, and he will not do it well if he pays the attention he should to the more important problems of production. He may, of course, be given clerical help; but this, again, is a palliative only, as the system falls down for other reasons. It has been pointed out in Article 63 that as shops grow in size the problem of cost-keeping becomes more and more important and, in most instances, when the problem of drawing material becomes too great for the foreman, it is high time to consider better methods of cost-keeping.

This leads naturally to the **preplanning** of work and the use of the **production order** (Fig. 6). Under these modern methods full bills of material are prepared either in the engineering department, the planning department, if there is one, or by someone in the office of the superintendent. These bills of material give full information [1] regarding the quality and quantity of the material and the order number to which it is to be charged. They are made in multiple, one copy going to the foreman with the drawings and other directions for the work and constituting his authority to draw the material. One goes to the storekeeper and constitutes his authority for issuing the material specified and serving also as the basis of costs. (See Article 71 and Fig. 6.)

The accuracy of the method is manifest. If properly operated it prevents unnecessary drawing of direct material, fixes respon-

[1] It is of course difficult to specify with great exactness all material required for some classes of work. However, the corrections necessary need not be great except in very complex work.

sibility and authority definitely, and in such a manner that errors or irregularities can be instantly located on those responsible. Most important of all it permits of more accurate costs than are attainable under the older methods.

The method is not flexible, however, and emergencies must be cared for by modifications of the plan. Small jobs would cost too much if passed through a system of this kind. It does not take account of expense material and supplies. For these reasons it is customary to give some foreman, or other official, power to issue emergency requisitions to care for these special conditions. Thus, in an emergency repair job brought into the shop on Saturday afternoon, or an imperative repair job on the shop power house on Sunday, when the machinery of the planning department is not running, this official would issue the requisitions, subject to the approval of the proper authorities when the office and store-room open up again. Emergency methods must always be provided, in any well-organized system, to prevent inflexibility destroying its usefulness. It is the fear of this inflexibility that often leads superintendents and foremen, charged with the duties of production to oppose new systems that savor of " red tape " because, while they may cure certain evils, they may do so at the cost of convenience and flexibility. This particular defect in all systems deserves careful consideration in installing them and it is in making modifications of this kind that the manager shows his true ability in organizing.

Expense materials and supplies, such as oil and waste cannot, of course, be handled on production orders. They may be issued on the foreman's order, but in no case should the foreman assign the order number to which they are to be charged unless classified standing order numbers have been provided for this purpose. (See Article 72.) Standard supplies, such as oil and waste, are often given out at assigned times only, and in definite quantity, to each man. Extra quantities may be drawn at other times by special order only.

Item (e). It is obvious that if the stores department is to anticipate the needs of the factory it must keep a fairly accurate

record of all material and supplies. If a planning department exists this need is accentuated, since skillful planning cannot be carried on without accurate record of materials on hand. The extent and detail necessary in such records will, of course, vary greatly with the business. In the case of continuous processes, or of manufacturing approaching a continuous process, where the material for the most part moves from the store-room directly through the factory without interruption, the store-room bins and racks may be considered as reservoirs in which the material should never fall below or rise above certain economical limits that have been fixed by the considerations already discussed.

Several methods are available for making intelligent use of such maximum and minimum limits. The simplest is that which may be called **observation of limits.** Usually only two limits are set, the maximum and the minimum, though sometimes a lower or "**danger**" limit is set for the purpose of indicating that orders for a fresh supply of material must be rushed. To keep account of the material a printed form is attached to each bin or rack and as material is withdrawn the storekeeper deducts the amount taken away, thus keeping a continuous record of what is left. When the amount falls to the lower limit an order is placed that will bring the amount up again to the maximum. In a more highly developed form the records are kept by the head storekeeper or his clerical assistant either on a card system or in a loose-leaf ledger, ruled specially for this purpose as illustrated in Fig. 17 and usually known as a **Stock Ledger.**[1] Each page records one part (or in the case of finished parts, one combination of parts) and, as can be seen, it records not only all receipts and issues of such part but also *such orders as are already placed* for more material of this kind, and also records any material on hand that has already been assigned to work in process or on order. When a material requisition is filled for the shop it is canceled and sent to the head storekeeper,

[1] As before noted the terms stock and stores are used indiscriminately in practice and the term stock ledger is used here in this sense to conform to common usage.

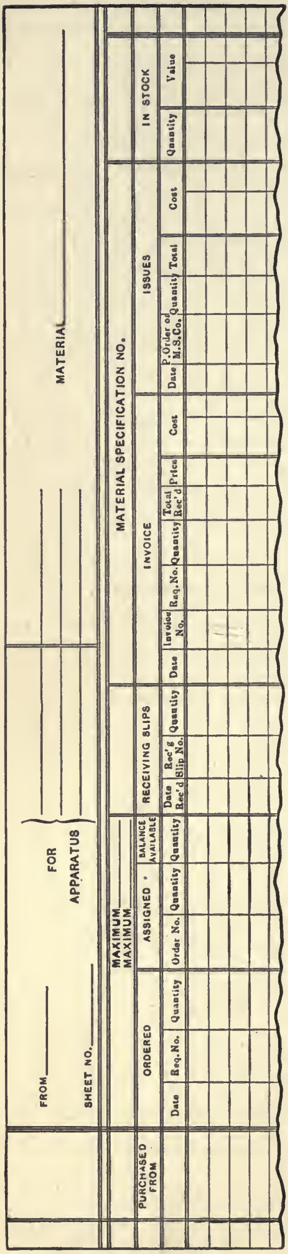

Fig. 17.—Stock Ledger Sheet.

no record being kept at the bin. All invoices, after verification by the receiving department, are also sent to him and thus all information regarding material and supplies is centralized at his desk.

This method is usually adequate for the needs of most plants; but there are cases where it is desirable to carry the process one step farther. It will be noted that the above general plan takes no note of material *in process of fabrication.* If the plant makes large quantities of finished parts of many varieties, or if the processes of manufacture are intermittent, it may be desirable to keep track of these parts in process in order to more intelligently order raw material and finished parts. Thus, a certain bin might be nearly empty but it would not be good policy to order, hastily, a large quantity of the finished parts belonging therein, if a large quantity was about to be delivered from some manufacturing department of the works.

For purposes of this kind a **stock-tracing ledger** is sometimes used. This may, of course, be of the loose-leaf type or may consist of a card system. On each sheet or card a record is kept of the movement of each lot of material from the time it first leaves the storeroom until it is finally delivered

as finished parts, thus supplementing the information contained in the stock ledger. It will be noted that in the more modern shop systems, using a planning department and routing board, information of this kind is always readily obtainable from the routing board. (See Article 57.) The stock-tracing ledger is, in fact, a continuous progress report of parts that are passing through the factory in lots. It may serve another valuable purpose, namely, that of showing what departments are behind in their work or are under-equipped either in tools or men as compared to the remainder of the plant.

It was formerly considered sufficient to take an inventory of the plant once a year. Modern methods demand that the accounting system keep close track of all changes in the value of the plant. It is not difficult to keep close records of changes in real estate, buildings and tools, but unless good stock ledgers, as described above, are kept, not even an approximation can be made as to the changes in the value of the materials and supplies. By these methods, however, a **continuous inventory** may be kept, the accuracy of which will, of course, depend on the detail to which it is carried. A space is always provided on stock ledger sheets for evaluating the material listed, as shown on the right-hand side of Fig. 17. Such inventories, while sufficient to show the trend of values should, however, be checked periodically by an actual count and visual evaluation.

It is obvious that the methods, blanks, forms, etc., that may be used advantageously in store-room and stock-room work will vary widely with the business and conditions, as indeed they necessarily must in all business organizations. The methods suggested in the preceding paragraphs have been included more to explain the problems met in handling material than to advocate them as the best for all cases. They are, however, in successful use in many places.

117. Economical Use of Material. The material wasted around a factory may be a serious source of loss, particularly if the material has high intrinsic value as in the case of copper and brass. These wastes may be due to several causes. It is not always possible to specify exactly just how much of a certain

material is needed for a job and, if a liberal amount is drawn, that left over after the completion of the job is seldom returned to the store-room, but collects on and under benches and out of the way corners. In certain kinds of work, as in punch press processes, the material left after the punched parts are removed is often as great or greater than the parts themselves; and, if the material is valuable, care should be taken to recover it. In all cases systematic and constant effort should be made to collect and store all scrap so as to recover as much value as possible, and also to keep the shop or factory clean.

In nearly every store-room will be found old material for which there is no apparent use. This comes, usually, from two sources. The first is over-ordering of material for special jobs. Special material is always a hazardous investment and care should be taken that no more is ordered than will give the minimum margin of safety. The second most important cause is a change in design. The engineering department can save a great amount of money by carefully considering the question of material. The standardization of parts, and the use of the same part as often as possible keep down the value of the inventory; and great care should be taken that no change in design is made that will leave raw material, finished parts or completed machines in danger of obsolescence. Obsolete material, raw or worked, depreciates very rapidly, completed machines often being worth less than the original cost of the materials of which they are composed. Before scrapping such material, however, a report should be sent to the manager, approved by all parties concerned, giving the inventory value, scrap value and loss, with the reasons and responsibility for such loss clearly determined.

The wasteful use of indirect materials and supplies is another source of great loss, especially in large plants. As before noted, it is a difficult problem to specify accurately, and supervise intelligently, the drawing of expense material from the stores. However, a cost-keeping system that furnishes accurate records of all expense material is a powerful means of regulating these expenditures. The purchasing of expense material best suited to the needs of the plant and their economical handling and use is

a fruitful field of study for the works engineer, and his labor will be greatly expedited by well-kept records of performance in all branches of the business from office to power house. (See Article 47.) The problem of waste due to poor workmanship is discussed in the next article.

Inspection of Materials.

118. Reasons and Basis for Inspection. As factories increase in size the problem of the careful inspection of all materials becomes one of increasing importance. In a small shop the purchase of material is usually conducted by a skilled man who *sees* what is purchased and if by chance a lot of poor material is purchased, the financial loss is not great. In large plants, where purchasing is specialized and conducted by specifications, it is of greatest importance that all purchased material is carefully examined before putting it into production, because here the loss may be very great. For the same reason it is also imperative that great care is used to insure accurate workmanship, where the quantities are great. In small plants it was, and still is, the practice to use the final assembly of the product as a check against poor workmanship and the final running test as a criterion of the fitness of the materials. Obviously, no such chances can be taken in mass production. Furthermore, there is always grave danger that, under modern intensive methods of production, where workmen are pressed by one cause or another to increase the output, the quality of the product will be lowered. This is common experience; any speeding up of productive processes must be safeguarded by careful checks upon the quality of the workmanship. A good inspection system will, therefore, check all material as to quality, quantity and workmanship, from the time it arrives at the store-room till it is placed in the finished stock-room; the detail in which this is accomplished, and the methods adopted for so doing, necessarily vary greatly with the industry and plant.

The requirements on which material is inspected may be based upon one or all of the following characteristics:

(*a*) **Quantitative,** *i.e.*, as to quantity or number of pieces.

(*b*) **Qualitative,** *i.e.*, as to physical or chemical properties.

(*c*) **Dimensional,** *i.e.*, as to accuracy of form or finish.

(*d*) **Salability,** *i.e.*, as to fitness of the finished product for the purposes for which it is intended.

In general, it is not convenient or desirable to have all inspection done in one department or by one body of men, and in most large plants it is divided into three distinct divisions, though the work of these divisions may overlap at times. Raw material is usually inspected by the stores department under the jurisdiction of the storekeeper; dimensional and other manufacturing inspection is usually conducted by the shop inspectors, who are directly under the superintendent; while the final inspection of the finished product may be under another head. In engineering works, and manufacturing based on scientific principles, the final inspection and tests of performance are usually under the direction of the engineering or designing department.

119. Inspection of Purchases. The skill and prudence of the best of purchasing agents may be greatly nullified unless all material received is carefully verified both as to quality and quantity. Many large works have a **receiving department,** which is usually part of the stores department, and under the control of the head storekeeper. Here all purchased materials are counted and inspected and all articles not up to the specifications on which they were purchased are rejected. This inspection may include visual examination as to quantity and quality or it may extend to chemical and mechanical tests, if necessary, to determine whether the materials are up to the standard paid for. In large works, manufacturing interchangeable apparatus, the careful inspection of such articles as taps and dies, machine screws and similar supplies is not only absolutely essential for the sake of interchangeability but is a source of great financial saving. If possible, it is also advantageous to be able to identify materials that develop defects in process of fabrication, so as to make such just claims on those furnishing them as may seem desirable.

120. Inspection During Manufacture. Inspection during the

process of manufacture should be organized with the following considerations in mind.

(*a*) To prevent unnecessary hand work on the assembly floor.

(*b*) To inspect mass-production operations in the beginning and often enough thereafter to prevent any great amount of material being spoiled.

(*c*) To prevent further work on parts already spoiled.

(*d*) To see that no parts are lost in transfer from process to process and that all are accounted for.

(*e*) To pay only for good work.

(*f*) To find and locate imperfections in machines and processes and lack of skill on the part of the workman.

(*g*) To guard against the natural tendency of intensive production to cause a lowering of the standards of accuracy.

Under the older and cruder methods machine parts were made as accurately as the tools available would allow and the discrepancies adjusted with the file or other hand tool at assembly. To-day, with the demand that exists for interchangeable parts, such hand work cannot be tolerated and with modern machine tools and measuring appliances it is not necessary, provided all parts are carefully inspected when made. Furthermore, it is more economical, where there is any considerable quantity, to spend a little more to insure accuracy in detail parts, thereby saving the annoying, and often very expensive, corrections so often experienced in assembling. It should be noted that the accuracy of component parts will depend largely on the accuracy of the tools furnished the workman. Not only the machine tools but all standards and gauges must be kept up to exactness if accuracy of product is to be maintained.

It is almost axiomatic that the first parts in mass production should be very carefully examined, and inspection made often enough to insure that machines and men are working up to the standards. Constant vigilance is needed where the parts are numerous to prevent large quantities of spoiled work. When any defective work is discovered it should be set aside at once and no more labor expended upon it until it is definitely settled that it can be used.

Every workman should account for all work turned over to him; and if the inspection shows that any has been spoiled the matter should be settled then and there. Each workman should be held strictly accountable for the accuracy of his product; but in judging of these matters great care should be exercised that the blame is not placed on the workman when, perhaps, it is not his fault, but the fault of defective gauges or standards or, worse still, faulty verbal instructions. Even though the workman is not penalized by deducting from his pay the value of the spoiled work a systematic record of such occurrences is not only valuable as a guide for future reference but has a salutory effect upon the workman. Furthermore, every effort should be made to remedy at once the cause of the defective work whether that entails correction in machinery or instruction to the worker. Very often the latter is not an easy matter to accomplish, but it is often better to try to help his weakness, and thus prevent a recurrence of the difficulty, than to be satisfied with reprimanding him or discharging him, to repeat the same performance with a new man.

Above all things, the inspection system should be a bulwark against the lowering of *quality* in order to obtain *quantity*. As before noted this is a natural tendency, under intensive methods. Before any speeding up is tried careful consideration should be given to the matter of inspection, and proper provision made in the way of gauges and means of applying them. Unless this is done haste will most assuredly make waste. On the other hand inspection will not cause a diminution in product if proper facilities are provided. Thus, to try to hasten the output of a lathe hand turning very accurate bearings, would be, in general, an open question, so far as the resulting accuracy is concerned. But the installation of a grinding machine in connection with the lathe would not only increase the production, but would make possible an accuracy not attainable at any rate of production by means of the lathe alone. Accuracy and output cannot be considered apart from the tools needed to produce them.

From the foregoing it is almost obvious that an inspection

system that will accomplish these results must, in most cases, be organized apart from the manufacturing proper, if it is to serve as an effectual check upon wastes and bad work. Usually, therefore, the head inspector is put directly under the superintendent or principal officer in charge of production and reports directly to him. (See Fig. 4.) Inspection by the foreman, or by workmen under him, is likely to be lax if not partial, since the foreman himself is, in a measure, responsible for the defective work. The inspector must be a man of firmness and decision, yet eminently fair in his judgment. His business should be to detect errors and defects and not to cure the troubles from which they arise, though his suggestions and recommendations may be very valuable and should be obtained. His authority regarding his own work should, however, be unquestioned and for these reasons it requires a man of ability to make a successful inspector.

The method of conducting the inspection of material as it moves through the shop, and the detail into which it is necessary or remunerative to go, will, of course, vary greatly with the requirements of the industry. The detail and accuracy necessary in producing fire-arms or watches would be, of a necessity, much greater than in manufacturing pipe fittings. This is a matter of judgment and cannot be fixed by rule.

Leaving out of consideration the several inspection methods that depend in some measure on the foreman, or some other member of the manufacturing force, there are two principal methods of conducting inspection, namely, by **traveling inspectors** or by **centralized inspection.**

In the first the inspector spends all his time on the shop or factory floor, moving from place to place as necessary, checking up the initial parts as they come from the machines and checking up the finished lots both as to quality and quantity as they leave or arrive at each process. In large works an inspector may be assigned to each department and special benches and platforms may be provided for his convenience in checking over the various parts. His approval or disapproval of the work is indicated on the tag that accompanies the work.

In the centralized method of inspection central inspection rooms are provided and all work is returned to the proper room after each operation. Here the inspectors work free from any influence of the shop. This method is an advantageous one where the parts are small and the limits of accuracy close, as in instrument work. If, however, the work is large and the parts heavy it is obviously unworkable and the extent to which one or the other, or a combination of both, should be employed is a managerial problem often requiring very good judgment. In general, if the parts are small, and the work of transferring them is not great, centralized inspection will be cheaper and more accurate; while, on the other hand, it may not be so effective in forestalling bad work as the traveling inspector system, for reasons that are obvious.

121. Performance and Assembly Tests. In practically all industries a final examination is made of the finished product before shipment or storage. In some classes of manufacturing, as, for instance, in making steam engines or electrical machinery, these final inspections and tests may cover not only the verification of refined scientific theory, but may include physical tests of the apparatus as well. As before noted, such final tests and inspections are usually made under the supervision of the engineering department since, usually, an engineer is alone competent to perform this work intelligently, and because the engineering department is responsible for the performance of the apparatus.

The requirements of the final test are often set by the purchaser, and he or his representative may be present at the test, taking such information or data as he requires to satisfy himself as to the characteristics of the product. Sometimes this authority is delegated by the purchaser to some insurance company. Thus, builders of boilers will furnish a paid-up policy in certain insurance companies for a limited period of time. Such a policy guarantees that the boiler has been built and inspected under the supervision of this particular insurance company, which in this manner becomes responsible for the performance of the boiler. The United States and other Governments always have a corps of inspectors detailed to inspect and

test all apparatus going into the construction of navy vessels when built by private contractors. Care should be exercised in taking contracts that the conditions of performance and test are not so severe as to be unattainable, or attainable only at an expense that would make profit doubtful.

122. Inspection in General. It should be noted that inspection in a general sense has a much wider significance than indicated even by the foregoing discussion. The general principles underlying it grow naturally out of the modern tendencies toward aggregation and specialization discussed in Chapter V. Under older and simpler methods the workman on day wage naturally took sufficient time to insure his accuracy, and the foreman or erection boss had sufficient time to check the work. Under high speed production and greatly increased number of parts these methods will no longer suffice. The foreman has neither time nor, in general, the information necessary to properly inspect the product. Division of labor must necessarily be resorted to as the complexity of production increases.

Furthermore, mistakes are much more costly as the number of parts becomes greater and as the design of the product becomes more scientific and complex. Careful inspection of all work, from that of the engineering department down to the shipping department may be justified. The careful examination of the scientific basis [1] on which machines are designed and the inspection of all drawings before sending them into production becomes a matter of great importance as the number of parts to be made becomes greater. The principle is universally applicable, but the extent to which it is desirable or remunerative to apply it is a matter of managerial judgment. If the limitations are intelligently decided, there is, as a rule, no difficulty in devising the necessary methods and appliances for a proper execution of the principle.

Inspection presupposes *preplanning* and definite *standards*. No inspector can be efficient unless he knows exactly the requirements of the part concerned and has the necessary tools

[1] The committee system, see Art. 48, is a powerful means of checking up errors in design and similar preliminary work.

and gauges to test its accuracy. It is a functionalized duty that goes naturally with well-organized and well-equipped establishments. The need of accurate gauges and measuring devices and the importance of keeping them properly adjusted is obvious.

References:

The following articles on store-rooms and inspection methods may be found helpful.

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CHAPTER XIII.

LOCATION, ARRANGEMENT AND CONSTRUCTION OF INDUSTRIAL PLANTS.

123. Industrial Engineering. The importance of the **location** and **arrangement** of industrial plants has not, in general, received attention commensurate with their economic value. In small shops that supply local demands **equipment** and **management** are no doubt the most important factors in economic production; but as plants have increased in size and markets have become more widespread, the problems of transportation of both raw and finished material and the economic handling of material in process have become increasingly important. Questions regarding power, labor, taxes and many others that may be comparatively unimportant in the small local factory assume greater proportions when a large undertaking is planned.

The older and still common custom of having the manufacturing superintendent plan and build additions to the plant, or even to plan an entire new plant, is no longer adequate for best results in large undertakings. The manufacturing expert may be a good judge of the necessary factory tools and appliances, but he is, in most instances, poorly informed regarding the latest economies in power plant construction or electric lighting and similar correlated problems that have become specialities. The location and construction of a large modern industrial plant may require the services of several specialized advisers, and the work of directing such experts is rapidly coming to be recognized as a business in itself and has been named **Industrial Engineering.**

124. Location of Plant. It is well known that industries of different kinds tend to concentrate in different parts of the country. Thus, spinning, weaving and shoe-making are among the great industries of Massachusetts and Rhode Island. Connecticut has long been a leader in brass goods, and Pennsylvania

in carpets. On the other hand, industry may move from place to place. In general, of course, industry will follow population. The centre of manufactures has moved steadily westward as the country has developed, being located by the census of 1900 [1] near Mansfield, Ohio. But, in addition to this general movement, entire industries may leave one locality and move to another because of economic conditions. Thus, the New England States are no longer preëminent in certain fields of manufacture that had their origin in that section, economic relations between raw material and markets having given more westerly states such a manufacturing advantage as to cause, in some cases, an almost complete removal of the industry to other localities. On the other hand, some of the older states have held firmly to manufacturing industries for which they possess no raw material, against all the competition of other states possessing not only raw material in abundance, but equal, if not better, facilities for transporting the finished product to market. The spinning and weaving industries of some of the New England States, the jewelry and silverware industry of Rhode Island and the brass industry of Connecticut are striking examples of this persistence. The trend of manufacturing, geographically, is, therefore, an important factor in locating an industry and is worthy of careful consideration in locating a new plant or moving an old one.

The causes that lead industries to concentrate in certain localities are obviously many and complex.[2] The most important of these causes are — **nearness to markets, nearness to raw materials, the supply of labor** and **cheap power** either from waterfalls or from cheap fuel.

The first two are of course fundamental. Without material, manufacturing is impossible and without markets it is useless. They are, also, of prime importance, economically, in localizing industry within a comparatively limited area. Other things being equal, industry naturally locates near the market it serves, since it must, necessarily, be the result either of a demand from

[1] See 12th Census of the United States, p. CLXXI.

[2] For an extended discussion of this matter see 12th Census of U.S., p. CCX.

the market or an effort to create such a demand. The location of the supply of raw material has usually, however, a modifying influence, and the result is often a compromise which is also affected greatly by the question of transportation. Clearly, there is no economy in shipping bulky raw material great distances if the larger part of it becomes waste in the process of manufacturing. For this reason industries such as paper making that depend on forest products are likely to be found near the forests. Packing houses are placed near stock raising centers and pottery industries near clay beds. On the other hand, wool grown in the western states can, perhaps, be more economically manufactured at present on the Atlantic seaboard. In the case of copper products the ore is reduced near the mine, since its transportation for any great distance is, in general, prohibitive. The ingot copper obtained in Montana, for instance, may be economically transported to Connecticut, manufactured into many kinds of products and the small portion of these products used in Montana shipped back to that state for consumption. It is also obvious that the influence of these two items, nearness to markets and nearness to raw materials, grows less as the question of transportation becomes less important economically. If the transportation charges are small then one or the other or both of the last two influences, labor and power, may be predominating factors and both raw material and finished product may be economically transported considerable distances to take advantage of the market. It is a rare instance, however, when the influence of any one of these causes fixes definitely the geographical location of an industry. Each case presents combinations of its own that must be carefully considered in making a decision. As will be seen, presently, these last two influences, labor and power, also affect the exact location of an industry within the somewhat wide geographical limits fixed by the above general considerations.

As before noted the economic conditions that lead to the establishing of an industry may change, especially in a new country like America. If these economic changes are great enough, they may so influence industry as to make it migrate long dis-

tances. On the other hand industries often persist and prosper long after the economic balance is apparently greatly against their location. Of the above-named influences that tend to give inertia to established industry, labor supply is, perhaps, the most important. It takes *time* to build up an industrial community and once built up it is not so easy to transport as it is to transport machinery. Skilled workmen will not, as a rule, leave their native environment without a considerable increase in wages and even then they easily become discontented and return home if the surroundings are not congenial. There is, therefore, a certain amount of **inertia** that attaches itself to industry when *it has once been successful in a given place.* Many of the early manufacturing enterprises of New England were started in one place or another simply by chance circumstances. The enterprise prospered, others grew up by imitation, or as branches, specialization brought in subsidiary occupations, a large amount of local capital became interested, the whole movement gathering an inertia that often more than compensated for lack of other economic advantages. It is by influences such as these that New England has stubbornly and successfully held the supremacy in certain lines of manufacturing, though the economic advantages leading to their establishment have in great measure passed to other states. In a general way people are likely to feel confidence in an industry that is being started in a locality where similar ventures have been successful and this adds to the momentum noted above.

It should be noted, however, that as any country develops industrially, as transportation becomes more effective and good labor supply more widespread, the intelligent location of manufacturing enterprises must be governed increasingly by strict economic considerations and less by inherited influences. This can be more readily seen by considering the establishment of a new industry in which the inertia of age has not appeared.

For these reasons, also, the water-powers and other sources of cheap power are sure to increase in value as coal becomes more expensive. New England owes her manufacturing greatness in no small measure to the manufacturing advantages obtained

from her abundant waterfalls. Cheap coal has given other localities an equal or greater advantage, temporarily; but these water-powers and others in the country are sure to be of increasing strategetic importance in the future and western cities that owe their existence to great waterfalls have, therefore, a reasonable assurance of continued prosperity as the country develops around them.

While the above considerations operate to locate industries within comparatively wide areas, some of them, in connection with other influences, must also be considered in fixing the exact location of the plant within the given area. Among the many considerations that may influence the exact location the following may be noted:

(*a*) Transportation facilities.
(*b*) Initial building requirements and possibility of expansion.
(*c*) Labor supply.
(*d*) Dependence on other industries.
(*e*) Financial considerations.
(*f*) Relative value of community restrictions and aid.
(*g*) Relative value of local markets.

A more coherent idea of the relative value of these several influences may be obtained by considering the relative merits of the three classes of location open to the prospective manufacturer, namely — **city, country** or **suburban.**

Cities being natural centers for trunk lines or water transportation usually offer superior advantages for obtaining raw materials and shipping finished goods. An abundant labor supply is obtainable as compared to other localities. If the plant is small and dependent on other industries as, for instance, repair shops, or some closely articulated industry, the city offers superior advantages, when these other industries are present, as they usually are. It is often easier to finance an undertaking in the city; cities offering better fields for obtaining subscriptions to stock or obtaining special inducements to locate, such as exemption from taxes or even large cash bonuses to assist in starting the enterprise. If the plant is small, and is supplying the local market alone, the city offers market advantages that would

not be so important to a larger plant. A plant located in a city enjoys municipal advantages such as good streets, sewers, gas, police protection, fire protection, etc.

As opposed to these advantages the city location has the disadvantage that land is high-priced, and it is very often difficult for large works to secure a site within a city where buildings exactly suited to the purpose desired can be erected without great expense; and if the city is a growing one the taxes in time make the location too expensive. This is one of the reasons why many factories have, within recent years, been compelled to move to the country or the suburbs. City restrictions regarding smoke and other municipal ordinances governing industry are questions that must be carefully considered. While labor may be abundant in the city the cost of living and hence the wages paid are, in general, higher than in the country.

The advantages of a location in the country are not so numerous as those of the city, but they are often of paramount importance. Thus, if a water-power is obtainable or if a supply of pure water is necessary, as in paper making, a country site may be very desirable. Land is cheap in the country and hence the factory can be built to suit the exact needs of the industry and ample provision made for growth. Taxes are low and restrictive ordinances not likely to hamper the activity of the plant. The larger the plant the less it is dependent on other industries and hence the country site, in general, appeals to the large operator more than to a small one. The local market is, likewise, likely to be of less interest to the large plant. Undesirable neighbors can be more easily avoided in a country location and the danger from fire and other hazards resulting from surrounding industries are also minimized.

On the other hand the labor supply of the country is usually a troublesome problem. The city offers advantages and amusements to the working classes that cannot be had in the country. An effort is often made to offset these attractions by building model factory villages where employees may acquire homes on easy terms and enjoy the healthful life of the country. Of course the employer that engages in such an enterprise must expect to

feel a greater responsibility toward his employees than he would in a city where the bond is much looser. But such work as this is worth while, and no doubt the near future will see a great amount of decentralizing of industry from the thickly congested centers in favor of country locations. Just as it is difficult to induce labor to leave the cities, so it is difficult to attract them away from good country industries if the conditions of life are made attractive; and labor troubles are likely to be less in a country location than in a congested city.

The suburbs of many cities offer a compromise between the city and country and possess many of the benefits of both. Land can be obtained at a price far below city property, and trolley lines have made living in the suburbs cheaper than in the city, and yet made it possible for the suburban dweller to take advantage of the attractions of the city. An examination of any of our large cities will show an immense amount of manufacturing in the suburbs, this location being particularly advantageous for fair-sized plants.

From the above it will appear that the city location, in general, offers greatest attractions to the small plant, the suburbs are best adapted to fair-sized plants, and the country offers by far the greatest attraction and fewest disadvantages to the very large plant, provided an adequate supply of labor can be obtained.

It is not possible to formulate the requirements of factory locations as regards levelness of the land, character of the soil, etc., since some of these vary widely with the needs of the industry. Some industries, such as ore concentrating plants, require a steep hill-side in order to utilize gravity. Other plants must have a flat plot of ground. One of the most successful plants that the writer knows of is built on solid rock at a considerable expense for excavating; another equally successful stands on made ground covering a veritable bog. If all the other economic features of the site are satisfactory these conditions are, in most cases, not so important unless the cost of preparing the site is excessive. Large cities have been built on very poor soil simply because of the strategetic importance of the spot or from the accident of original location. Care should be exercised,

however, that the factory site chosen is well protected from such occasional accidents as floods. One of the largest manufacturing companies in this country has lost large sums of money by occasional inundation and has spent large sums in making its site safe against periodic occurrence of such disasters, the plant being now so large that it would be too expensive to move elsewhere.

Arrangement of Buildings and Plant.

125. Adaptation of Building. The degree to which it is *possible* to adapt a building to the exact needs of an industry will depend upon the *character* of the industry; the *desirability* of adapting a building to conform closely to the needs of any given line of work will depend upon the probable *permanency* of the industry. Most enterprises that start in a small way begin work in rented quarters. Owners of such buildings most naturally build them to suit *average* conditions of manufacture and are usually averse to making changes that destroy their flexibility. Anyone acquainted with urban manufacturing has seen many efforts by manufacturers, that have acquired such properties, to remodel them to suit their needs more closely; and it is common experience that when a manufacturer builds a new plant to replace his old one he most naturally makes a strong effort to adapt the new plant closely to the needs of his business. It is coming to be more fully realized that the factory is not simply a building to house machinery but is an integral part of the manufacturing equipment and may exert a great influence upon economic production.

It was noted in Article 40 that manufacturing methods may be divided into **continuous** and **intermittent** processes. In continuous processes the material goes in at the receiving end of the plant, is worked continuously, and appears at the shipping room as finished product. In intermittent, or interrupted processes, various materials may be worked to varying stages of completion and stored away, the machinery working on one article today and another tomorrow and assembly into finished products being carried on as is found necessary.

Buildings are more easily adapted to fit the needs of continuous processes than to those of any other. This is well illustrated in ore concentrators where the building usually conforms closely to the requirements of the machinery it encloses. Sugar refineries, flour mills, steel rail mills and packing houses are examples of continuous industries where buildings often are closely adapted to the needs of the industry, and may often be so closely adapted as to be useless for any other purpose. At the other extreme are many industries that consist principally of assembling operations, little machinery being employed, and that of small size, the entire business consisting of small self-contained production centers. Floor space is the principal requirement and, within limits, the building may be any shape. In some of these industries the density of the workers is almost the only limiting factor, so much so that legal restrictions are in force in many states to regulate the congestion possible in these callings. Between these extremes come all manner of manufacturing processes, each presenting a different combination of needs. The possibility and desirability of adapting the building to suit these needs cannot, in general, be formulated, the best solution usually being a compromise that cannot be arrived at without intimate knowledge of the manufacturing problems presented and the financial conditions of the owner.

126. Arrangement of Equipment. The construction of a building perfectly adapted to a given industry presupposes a perfect knowledge of the character and capacity of the several machines or processes to be used and the logical arrangement that must be made with them so as to carry the material through the plant most economically.

In continuous processes this information is comparatively easy to obtain since the capacity of each machine or set of machines devoted to any part of the work must bear a definite relation to other machines or groups of machines, or the other factors of the process; and the nature of the process usually dictates the natural sequence of operations, or suggests such handling or conveying devices as may be needed to keep the process continuous. In the other extreme cases, where assembling

is the predominating factor, the problem is still easier; since here sequence is not a factor, the production units are small and the output a computable quantity. In intermittent manufacturing, however, this problem is often most difficult and always deserves more consideration than is usually accorded to it, not only in securing a *balanced* equipment but also to obtain any approach to a *flow* of material through the plant with a minimum of transportation expense. Obviously, here, also, no definite rules or methods can be evolved for solving such problems but there are certain general principles that apply to all plants and which may be worth noting.

In planning new buildings, or making extensions to old ones, it is quite common practice to calculate the new floor space by reference to other plants of the same kind. The floor area per ton of output, the floor area per employee or the floor area per dollar of output are often taken as standards for determining new floor area. Clearly, such standards should be used with care, especially if they are taken from plants of which the designing engineer has little or no knowledge. Such data are very valuable if their source and limitations are known but in all cases they should be used with caution. Conditions vary greatly in different plants making the same article. The degree of integration[1] may be vastly different, the equipment either more antique or more modern. New tools, new methods and new pay systems may make any calculations based on old performances useless. It is much safer, usually, to base all such computations of output on the actual capacities of machinery and processes to be installed, adapting the building to suit the arrangement of the same as far as desirable.

There are two distinct methods of grouping machines that strongly affect not only the arrangement of the factory but also its administration. In the first method all machines of the same kind and approximate size are grouped together. Thus all lathes up to 24-inch swing may be in one group, all semi-automatic lathes in another, all large lathes in another, all planing machines in another and so on. In other words the arrangement is based

[1] See Article 113.

on the **processes performed.** In the second method the arrangement of tools is based on the **character of the finished product.** Thus, a department building arc lamps would have its own equipment of machinery, specially adapted to its needs, another building transformers would have its own equipment, another building switches would have its own equipment, each entirely independent of the other and each department in a measure self-sustaining as far as machine processes are concerned.

It is almost obvious that the first method, if applicable, is by far the most economical. Fewer tools of a given kind will be required, since the possibility of keeping all machines in continuous operation is a maximum under this method. The cost of superintendence will be less and the workmanship, in general, will be better since the possibilities of specialization are greater with this arrangement. It is to be especially noted that the success of this form of machine grouping rests to a large extent on the accuracy with which the machining is done; and that again depends on the equipment of gauges and standards. Modern refined methods of machining with limit gauges and other accurate measuring devices have made this form of grouping possible to an amazing degree as compared with former manufacturing facilities. A rigid application of this departmental principle is seldom possible or desirable, however, and many departments devoted primarily to one kind of work often need a few tools of another kind for emergencies, or to save time. Thus, an erecting floor must often have a few drill presses or lathes, near by, where corrections and adjustments can be made. In refined continuous manufacturing this form of grouping is often carried out almost to perfection. In intermittent manufacturing compromises may have to be made and a careful consideration of the relative merits of the two methods will often save money in equipment and greatly facilitate production.

When the equipment of each department has been selected, with the above considerations in mind, the internal arrangement of each department can be completed tentatively, at least, due consideration being given to transportation, storage, power, etc. The floor space so determined can be compared with similar departments if such data are obtainable.

Particular attention should be paid to the safety of the employees if the machinery is of a dangerous nature. It pays, in all cases, to provide ample room around machines, or in shops generally, so that work is not crowded together too closely; and if safety of life or limb is concerned extra care should be exercised that there is ample room to handle the work in safety.

127. Sequence of Processes — Routing. With the equipment of the several departments selected and tentatively arranged it will remain to arrange the several departments with reference to each other so that the material will pass through the plant with a minimum amount of traveling and handling, and so that the factory shall work smoothly as a whole. This conception of the plant itself as a *machine* is a helpful one. There are many existing factories where a careful analysis and rearrangement of the plant along the lines suggested would work wonders. Old factories that have grown up from small beginnings are very likely to be organized too much according to *personality*. While personality is valuable in itself, it is not sufficient. A chief engineer may be exceedingly able, but he cannot produce power economically unless his machinery is of the right kind and properly arranged, and the same idea applies equally well to manufacturing.

As before noted, the ideal sequence is obtained in some continuous processes, the building following the sequences naturally or the two being mutually adapted to each other. This is well illustrated in Fig. 18 which shows the cross section of a stamp mill for working gold- and silver-bearing ores, and built on a hillside in order to use the force of gravity in carrying the ore through the processes. The building is made to conform closely to the needs of the process, not only as to housing the machinery but as to supporting the shafting, etc. The building is, in fact, one element in a large machine. The ore is delivered from cars to the bin *A*, passing thence through the rough-crushing rolls *B* to the bin *C*. From this bin it passes through the stamps *D*. Water is added during this stamping process and the finely divided product consequently runs easily down to the concentrators *E* where the lighter particles of rock are removed, the ore

passing on to the tanks *F*. From here the ore passes into the grinding pans *G*, where it is still further reduced in fineness in contact with mercury, the latter amalgamating with the free

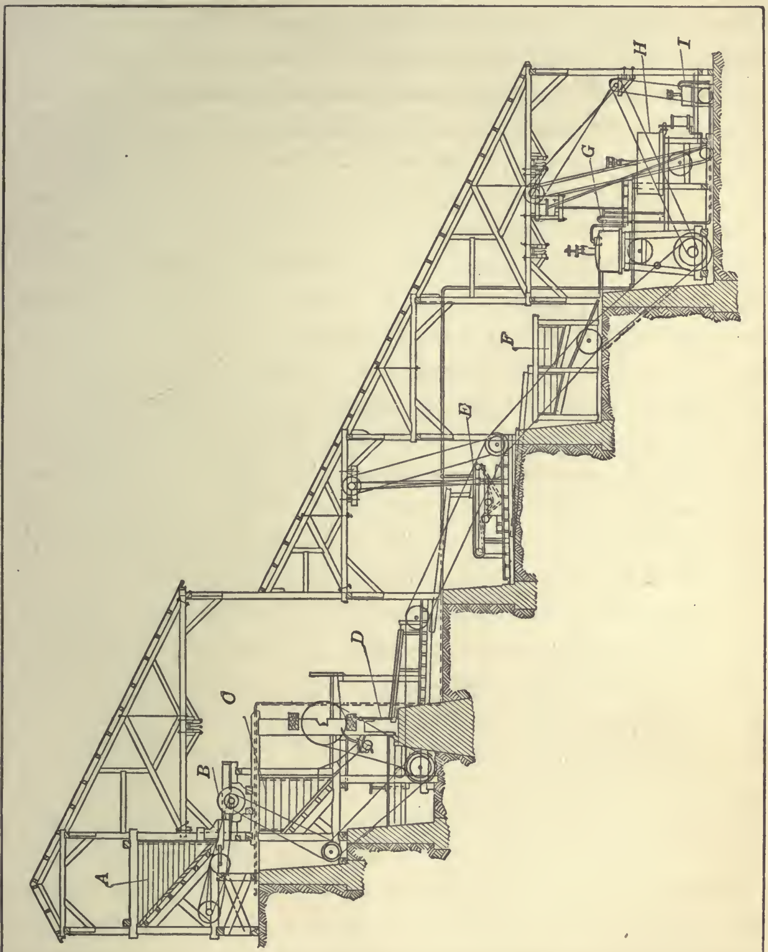

Fig. 18. — Continuous Process Stamp Mill.

gold[1] and silver and forming an amalgam that is separated from the waste rock by gravity action in the settling and clean-up pans *H* and *I*. The mercury is distilled from the amalgam

[1] Some of the free gold is caught by amalgam-covered plates at the stamp.

in a retort placed in an adjoining building, not shown, and the remaining bullion is cast into ingots.

It is obvious that no such sequence or adaptation of building can be secured in the average case of intermittent production, many compromises usually being necessary. The general principle, however, should be applied as far as possible, particularly if a well-developed planning and routing department is proposed. This is true, not only of factories housed entirely in one building, but also of large plants occupying many buildings, with the added consideration of proper yard room and perhaps railroad connections. One application of this general principle is shown suggestively in Fig. 19, which may represent any machine works making a line of product, such as steam engines, in many sizes, large and small, and of several varieties. Here the material comes in at *A* and the finished product goes out at *B*, the general movement being from right to left, and motion in the reverse direction occurring only where storage is necessary; though even this can sometimes be obviated or minimized. In addition to the standard railroad connections shown the plant would be equipped with an industrial railway for internal transportation and, of course, with cranes and other handling devices.

As plants grow in size these principles may be of increasing importance, particularly if the work approximates a continuous process. Thus, in the Gary plant of the Indiana Steel Company the open hearth furnaces are set at an angle with the blast furnace and finishing mills in order to obtain an arrangement of tracks over which material can be transported at a high rate of speed.[1] In other large plants, on the other hand, these principles cannot be applied to the plant as a whole. Thus, the works of the General Electric Company at Schenectady manufacture such a variety of goods, in so many sizes, that flow of material through the plant as a whole is out of the question. In this plant the buildings are placed, for the most part, at right angles to a central avenue, and transportation between shops is effected by a very complete system of electrically operated cars. If a part is to be moved at all on a car it makes little dif-

[1] See System, January, 1909, p. 10.

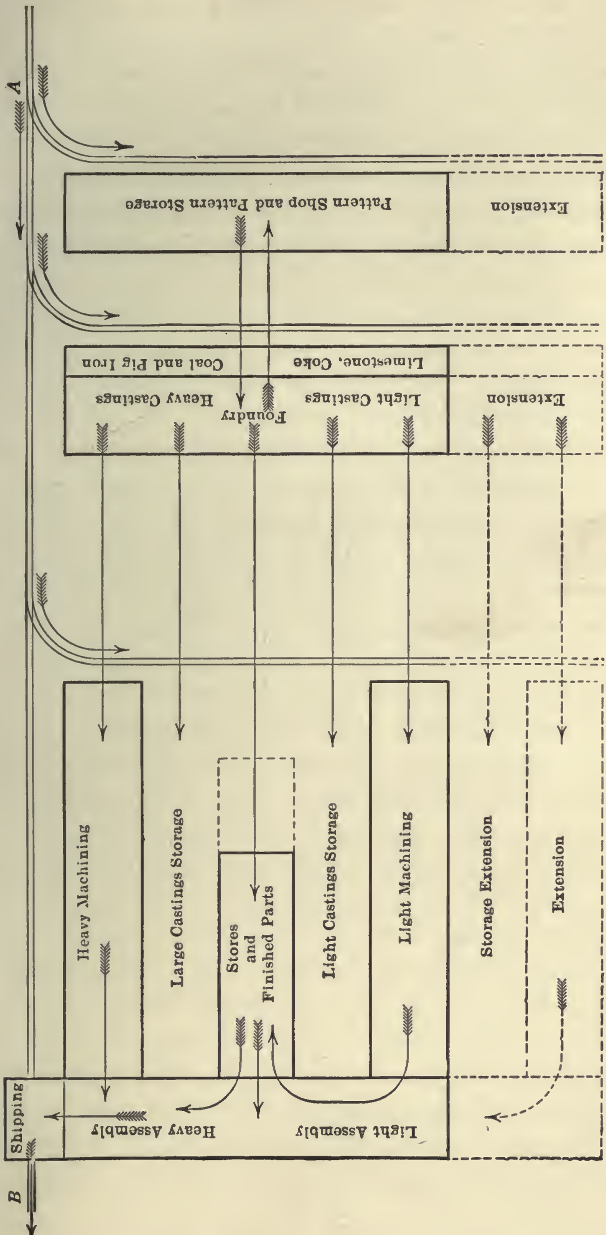

FIG. 19. — DIAGRAM OF FACTORY FOR INTERMITTENT PROCESSES.

ference whether the destination is in one shop or another, once it is placed on the car.

If the plant under consideration is a new one care should be taken to provide ample facilities for additions and extensions in such a manner that the equipment may be kept balanced without serious rearrangement. Thus, in Fig. 19, extensions,[1] such as are shown by the dotted lines, can be made without changing the original plan of the works. An ideal building plan is one built on some " unit " system, like a sectional bookcase so that additional units can be added at any time without disturbing the manufacturing system and organization. A little forehanded planning of this kind will often save large sums when additions or extensions are necessary.

128. Building Construction. The machinery that is selected and its arrangement will determine the characteristics of the building as to size, strength and general structure. Experience has reduced the types of factory buildings to a comparatively small number but a brief discussion even of these few types is beyond the scope of this work. It is evident, however, that buildings of any one type will vary greatly depending on the character of work they house and with the financial condition of the builder. Not even approximate rules can be laid down as to what the structural characteristics of a building must be to best solve the problem in hand. There are, however, certain general considerations that should be kept in mind in designing any factory building, aside from the consideration of strength and stiffness against vibrations, namely:

(*a*) Fire protection.

(*b*) Good lighting, heating and ventilating.

(*c*) Sanitary conveniences for employees.

(*d*) Appearances.

Volumes could and are written on each of these items, but the briefest mention must here suffice. It is unnecessary to urge the need of a careful consideration of the danger of fire in planning any building and of considering the danger of a conflagration

[1] The works of the Allis-Chalmers Co., at Milwaukee, are laid out on a plan similar to Fig. 19.

spreading from one building to another. The modern tendency is toward fire-proof structures of steel or concrete or combinations of these materials, though good results may be obtained by the slow-burning timber construction so common in New England mills. Too much care cannot be bestowed upon fire-fighting appliances, such as sprinkler systems, and most of the large manufacturing plants have not only elaborate systems of this kind but keep a completely equipped fire engine and well-drilled fire companies.

It is impossible to over-estimate the value of abundant light, heat and ventilation. These things were looked on, only too often in former days, as luxuries, and the cold, dark, ill-smelling shops so common a few years ago were in most cases mistaken efforts in economy. It is true that modern building construction has made the lighting of factories a comparatively easy matter, but it is important that builders keep in mind that light, heat and ventilation *pay dividends*. Great care was taken in times past that clerks on small salaries were comfortably housed, and they would not have been expected to do good work unless so cared for; while high priced mechanics were only too often expected to produce good results in spite of all sorts of physical discomfort and inconveniences. There is no difference between the psychology of the office and that of the shop. Workmen can, naturally, produce more and better work in well-warmed, well-lighted and well-ventilated rooms, and this is in no small measure due to an improved *mental outlook* that necessarily goes with improved physical surroundings. In the case of grinding, buffing and similar occupations many states have passed stringent laws making proper ventilation of such machinery compulsory. (See Art. 16.)

The question of sanitary conveniences for workmen, facilities for washing and changing their clothes, and similar features of the care of employees other than those discussed above have been fully discussed in Chapter IV and are referred to again in Chapter XIV. They will, therefore, not be elaborated at this point.

There is a growing sentiment that factory buildings should present as good an appearance as possible. It is true that

architectural beauty is difficult to attain in many industrial structures but many factory buildings are most unnecessarily ugly. Just as a well-designed machine is pleasing to look at, so a well-designed factory building may be just as pleasing, and at a small additional expense. It is to be hoped that decentralization of industry from the large cities may result in more model industrial villages, and that the old factory town with its prison-like factory buildings and bleak and barren looking tenements will soon, forever, be a thing of the past.

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Principles of Industrial Management, by John C. Duncan.
Factory Organization, by Hugo Diemer, Chapter 3.

CHAPTER XIV.

RÉSUMÉ — THEORIES OF MANAGEMENT.

129. Business Failures. In the year 1912 there were 15,299 recorded[1] business failures in this country, involving liabilities amounting to $202,219,352. Of these failures 3781 were in manufacturing enterprises involving liabilities amounting to $88,488,412. Many industries, of course, fail through losses incurred from causes that the owner cannot avert as, for instance, from floods, earthquakes, changes in tariff, new inventions or from competition from those possessing vastly superior advantages. No doubt, however, the majority of these failures are caused by incompetence of one kind or another and particularly by that form of incompetence that comes from *lack of knowledge* of some part of the business.

The following table compiled from Bradstreet's[2] gives some interesting statistics regarding the causes of business failures. In compiling such statistics Bradstreet's includes only such failures as result in financial loss and not those that fail to succeed without loss.

TABLE 12. — CAUSES AND PERCENTAGE OF FAILURES.

Causes of failures.	1907	1908	1909	1910	1911
Lack of capital	37.1	34.2	34.5	33.9	31.4
Incompetence	22.6	21.6	24.2	26.6	27.0
Inexperience	4.9	4.0	4.9	4.4	4.1
Unwise granting of credit	2.3	2.0	1.9	1.7	2.0
Speculation	0.7	1.0	0.8	1.0	....
Personal extravagance	0.9	1.0	0.9	0.7	....
Neglect of business	2.5	2.2	3.0	2.5	2.2
Fraudulent disposition of property	10.1	11.5	10.8	11.2	10.6
Specific conditions (disaster, etc.)	16.3	18.9	15.3	14.4	16.9
Failure of others	1.4	1.8	1.2	1.0	....
Competition	1.2	1.8	2.5	2.6	2.9

[1] See extract from Dunn's Report, in World's Almanac for 1913, p. 278.

[2] See Bradstreet's, Jan. 21, 1911, and Jan. 27, 1912.

It will be noted that lack of capital is by far the most important cause of failure, incompetence ranking next in importance. Furthermore, the first eight causes listed are all causes that are due to faults of those failing; while the last three, only, are due to causes beyond the control of those failing. The entire first eight causes may really be considered as forms of incompetence. The percentage of the first class as compared to the second class for the years noted above are: 1907, 81.1 to 18.9; 1908, 77.5 to 22.5; 1909, 81 to 19; 1910, 82 to 18; 1911, 80 to 20. It will be noted, therefore, that four-fifths of the failures are due to faults or incompetence on the part of those failing. It will also be noted that the proportion of those that fail because of pure incompetence tends to increase, having risen from 22.6 per cent to 27 per cent in the period noted above. These statistics should certainly furnish food for thought.

Industries are organized primarily for the purpose of obtaining a return on investment. The three great branches of productive industry are Financing, Manufacturing and Selling. It is not enough that the manufacturer have a knowledge of one or two of these; he must be versed in all three so that these functions may, like the gears of a machine, work smoothly and accurately together. Without doubt many failures are due to a lack of knowledge of the broader problems of industry in all three fields. Many enterprises are built up by men who rise from the ranks. In general, the man who has worked at the machine or the bench is well versed in the manufacturing side of the industry and is, usually, not so well informed in sound principles of finance and sales. It is not surprising, therefore, that many enterprises outgrow their founders and either fail completely, or pass into more competent hands. A discussion of the more refined principles underlying the organization of successful selling or financial departments is beyond the limits of this work; but there are certain fundamental principles underlying economic production that will be noted and that in a general way are applicable to all forms of organization.

Every manufacturer must expect to rest his chances of success on one of three general factors, namely, **monopoly, quality** or

price. Thus, he may possess valuable patents or control natural resources that give him a great advantage, if not complete control, over some desirable commodity. Refined methods of manufacturing and selling may not be of great interest to him. Again, he may appeal to the public to purchase his goods on the ground of quality. There are many manufacturers in this country that have built up large enterprises, against strong competition, by supplying product so good that all, who are able, buy it in preference to cheaper goods of the same kind. To such a man refined methods are highly important, for if he can make his high grade product for little more than the inferior kind his chances of success are increased; though, no doubt, there is often an advertising advantage in asking a good price for a good article, and avoiding the appearance of competition with an inferior brand.

If, however, the manufacturer is competing in the open field on the basis of the lowest price for a fair quality of goods there is no item in either manufacturing or selling too small to merit his careful attention. The market prices of goods possessing no special merit, and sold under competition, are always so low that the margin of profit is small even with good methods and allows no margin for poor methods. In fact, these prices may be so low as to allow no profit except under the very best conditions, and once these prices have been established it is difficult to raise them; "the trade will not stand it." One of the reasons why it is difficult to raise prices, as a whole, is because of ruinous competition by men who do not know what their costs are, or who are purposely losing money on one line of trade to hold trade in others; or for other similar reasons. The competitive manufacturer often cannot make his price on the basis of his costs, as he would like to have them, but must make his costs *come under market prices.* As already noted[1] it does not help him to know that his competitor is in time "going to the wall" because he knows that others equally incompetent will quickly take this competitor's place, thus holding the market price crystallized. It is in competition of this kind that absolute

[1] See Article 63.

knowledge is necessary and every refinement must be practiced. A full knowledge of the conditions in the market sought is, therefore, imperative.

Theories of Management.

130. Scientific Methods. As enterprises grow in size the problems of administration and management become increasingly important and require greater consideration. The small grocer can very well be his own porter, clerk and cashier, and can effectively perform all of these functions. But as his business begins to grow he begins to deputize the manual side of his business by hiring a porter; and as further development arises he deputizes a part of his mental work by hiring a bookkeeper. This process continues till, if his business is to succeed, he must **organize** it in some definite, systematic manner, reserving to himself **supervisory** duties only. It has been said that the secret of successfully managing a large enterprise is to **organize, deputize** and **supervise.** No doubt this does express in a rough manner the fundamental laws of successful management, but it may be of advantage to enquire more fully into the details of management.

Management may be defined as the art of applying the economic principles that underlie the enterprise under consideration. It makes itself manifest through organization; and since the principles underlying various enterprises vary greatly it is natural that forms of organization must also vary greatly with the character and magnitude of the business considered. Now it would seem reasonable to assume that if the economic laws or philosophy underlying the accomplishment of any undertaking can be discovered and recorded they will form a guide for the management of all similar enterprises. It does not follow, however, that *any* man who knows these economic laws can be a successful administrator. Two men may be given the same equipment of machines and knowledge, one will be successful and the other will fail. The basic facts or laws of any field are *impersonal,* but their execution or administration almost always involves personal qualifications on which success or failure may

and usually does depend. In other words, there may be a **science** of management and an **art** of management just as there is a science and an art in house building, aviation, agriculture and other lines of human endeavor. The question as to how far the art of management may be considered to have *scientific* foundation has been the cause of a considerable discussion which may bear further investigation. This naturally leads to an inquiry as to what constitutes a scientific foundation in any activity.

The fundamental laws that underlie any art may be known **qualitatively** or **quantitatively.** Thus, a chemist may know that if a certain acid is added to a given mixture a certain substance will be precipitated. An engineer may know that all beams will deflect when loaded. If, however, the knowledge of the chemist or engineer does not go beyond these limits, the fundamental laws governing these portions of their respective arts are known qualitatively only. Qualitative knowledge is often expressed **empirically,** that is, in terms that approximately express the true relations that exist between the causes and effects considered. The literature of engineering abounds in such empirical statements.

If, however, the chemist can say that a given weight of a certain acid will precipitate a definite amount of a certain material from the solution under consideration, the law is known quantitatively, and fully. In a similar way if the engineer can predict that a given weight will deflect a given beam a definite amount, he knows the law of the deflection of such beams quantitatively, also.

The principles that underlie any art become known through **experience** and the degree to which they may become known depends largely on the amount of such experience and the efforts made to record and interpret the same. In the early stages of any art such knowledge of the fundamental laws as may exist must exist as part of the personal knowledge of some man or men. And even after these laws are well known quantitatively they are still often preserved by being passed from father to son, or from workman to apprentice, without record of any kind.

Quantitative knowledge, however, involves the **measurement** of cause and effect, and laws are fully known only when such measurements have been made in sufficient number to demonstrate beyond doubt the exact quantitative relations existing between the phenomena considered. And it is only where the laws of an art are fully known both qualitatively and quantitatively that it can be said to rest fully on a scientific basis.

If, also, the qualitative characteristics and the quantitative measurements of any law are fully known they afford the means of **predicting** with certainty the results of similar operations under the determined laws, and if these characteristics and measurements have been systematically arranged and recorded they become **impersonal** and useful for all men. As the basis of any art becomes more scientifically developed the art becomes less and less dependent on personality; for scientific investigation consists, in part, of separating facts from personal opinion. This point of view is important in attacking any problem, even when the laws involved cannot be fully determined. The **scientific method** which first collects all the data or facts concerning the problem, analyzes them and deduces therefrom logical conclusions and then applies these conclusions to the prediction of results, is of supreme importance in all kinds of work. Scientific management, so called, is not a code of rules as much as it is an attitude of mind that aims to replace "I think" with "I know;" and the extent to which this can be accomplished will depend on how far the principles involved can be developed quantitatively.

It should be specially noted, however, that scientific data and system can never take the place of personality as might be inferred from some of the literature on the subject of industrial management. Personality has always been and will always remain the great moving force in human affairs. But personality alone is no longer sufficient where classified knowledge is a factor in the affairs considered. The personality of a Napoleon could never offset modern machine guns and the advanced sanitary methods of guarding the health of troops. The personality of the greatest physicians is often a small thing compared with

the cold science and skill of the modern surgeon. All other things being equal the advantage rests with the man that possesses the greatest amount of scientific knowledge. This statement has been proved in so many fields, from warfare to housekeeping, that it needs no defense and little explanation. And it is evident that the foregoing discussion applies to all kinds of human activity and gives us a standard by which all such activities may be measured as to their scientific basis. It remains to select some of the more important principles underlying industrial management with which this treatise is concerned and apply this criterion to them.

131. Economic Principles. The principles underlying industrial management are, in general, obviously many and complex; but among those that underlie economic manufacturing the following are perhaps the most important. (See also Article 40.)

(1) The **principle of division of labor,** including separation of mental and manual labor, and the subdivision of both mental and manual labor.

(2) The principle of **transfer of skill.**

(3) The principle of **transfer of thought.**

(4) The principle of **coördination of effort.**

(5) The relation between **unit cost and the number of parts produced.**

(6) The **systematic use of recorded experience.**

(7) The principles **governing human relations.**

As before noted any or all of these may be applied to the general problem of the several fields of productive industry such as sales, factory construction, factory organization, and factory operation, or they may apply equally well to the details of the organization of any single department. And, as before noted, also, the degree to which they may be *scientifically* applied will depend on the extent to which they are known qualitatively and quantitatively with reference to the case in hand. They can seldom be considered independently, since their effects are usually closely interconnected. And, most usually, they are known qualitatively only, the cases where any one of these prin-

ciples is fully known quantitatively being the exception and not the rule.

Division of labor, for instance, is well known in a qualitative sense. Long experience has taught men that when they specialize closely they become more expert and more productive. But there are no data, no measured results, that indicate the relative merits of different combinations of divided labor or the relative gain by any one combination over performances where each man does many functions. Again, in organizing any factory or industrial enterprise the manner in which the work is divided is often greatly influenced by the personality of the men available; for, as yet, men cannot be measured and selected to fit the circumstances but the work must often be arranged to fit the man available. Men cannot be obtained by specification as can steel.

Furthermore, the manufacturing processes involved in the production of a part may have a great influence on the extent to which division of labor should be employed, since division of labor is greatly affected by the machines, tools, jigs, etc., that are employed. These in turn are governed largely by the number of parts that are to be made. There are limitations, therefore, to the extent to which division of labor may be economically employed if for no other reason than that there are financial limitations to the tools and fixtures that can be economically made for the work. One of the chief criticisms of the many "systems" of organization now being advocated is that they do not recognize these limitations. Too many of the advocates of these systems think in terms of mass production only and as a consequence some of these systems are of little use to the small manufacturer, if, indeed, they are not often actually harmful.

A knowledge of the limitations of a system is often as important as a knowledge of its advantages and the intelligent choice of military and functional principles for the building of a successful organization will depend to a large extent on a recognition of the limitations that exist in each principle for the case considered. Obviously, the general principles governing division of labor are at present known only qualitatively and it is questionable if they

will ever be so fully known quantitatively as to be wholly impersonal.

The engineering department of a manufacturing works is a fine example of the application of some of these principles. Here the character of the mental work that is separated from the other kinds of labor incident to production and delegated to the engineering department is clearly defined and hence the character of the personnel of the department is also clearly defined. The laws underlying the work of the department are, to a large extent, known both qualitatively and quantitatively. These have been fully developed by scientific investigation and measurement of the principles concerned, and prediction of results based upon them can be made with some degree of certainty. When the results of the mental labor done in the engineering department are transmitted to the production department, they are definite and impersonal and obviate all *engineering* knowledge on the part of those delegated to construct the product. The work of the department is, in best practice, closely coördinated with that of the other departments by the methods discussed in Chapter VIII.

The work of the tool department is also a good example of the same principles illustrated by the engineering department. The work delegated to this department is partly mental and partly manual; and the result of the efforts of the department is a transfer of skill to the production department in the form of jigs and fixtures. The science of tool making is fairly well defined. Viewed broadly, it is a branch of the science of building and equipping industrial plants. The financial basis on which tool-making rests is, however, closely connected with other factors that will be discussed elsewhere.

The principles of coördination of effort have already been discussed at length in Chapter VIII. The principle of coördination is well illustrated in the work of the designing department where many parts drawn on many different sheets are designed so as to coördinate perfectly in the completed product. In a similar way the tool-maker plans the several operations on a given part and makes his fixtures accordingly so that each operation co-

ordinates with all the others in producing the shape and form desired.

Coördination of effort of men and departments with reference to *time*, is, however, a much more difficult matter. The methods that have been developed for accomplishing this result have already been discussed in Chapters VIII and IX and will not be repeated here. Brief reflection will show that these principles must always remain, of a necessity, more or less qualitative in character. Coördination of effort comes as a direct result of division of labor, and becomes increasingly important as division of labor is extended. But, as has already been noted, the principles of division of labor are not, and probably never will be, divorced from personal attributes. Administrative problems are not definite and quantitative as are the problems of design; and as the extension of division of labor introduces complex personal relations, so the coördination of effort made necessary by this extension is even more complex. Card systems, reports and committees do, of course, greatly assist in coördinating the work of the several departments; but there probably never will be one *best* way of doing this, and personality must always remain a powerful factor in this part of the field of organization. Here, as in division of labor, it is important to note carefully the limitations of any system or clerical machinery that may be introduced to accomplish coördination. The failure of enthusiastic systematists to recognize the proper balance between system and personality has caused the downfall of many systems and the loss of much profit.

The work of Mr. F. W. Taylor discussed at some length in Chapter IX is a most masterly effort to apply these principles more fully to the problem of actual production as occurring in metal-working establishments. Functional foremanship is simply an effort to separate mental and manual labor and to subdivide each as far as possible. This naturally carries with it the necessity of transfer of thought and transfer of skill; the result of preplanning by the planning and tool departments. But when Mr. Taylor began his work, the scientific basis necessary for the successful prediction of results was entirely lacking, the prin-

ciples underlying the machining of metals being entirely in the qualitative or empirical state. By means of time and motion study Mr. Taylor was able to collect sufficient data and to deduce therefrom *quantitative* statements regarding the cutting of metals that enabled him to use division of labor to an extent hitherto unknown in the machine trades and comparable with the method long in use in the designing department.

It was, of course, necessary to provide more powerful coordination of effort with this extension of division of labor and this was provided by his highly developed routing system. This routing system aims not only to have every operation performed at the right time, but also aims to have every machine, and every man occupied as steadily as possible. The whole conception of the plan is perfectly logical and clearly thought out. It is in perfect accord with the best economic theory of production. It is true that there are no new principles involved, but the *application* is new and Mr. Taylor's work in pointing out the possibilities of extending these principles to new fields and other lines of work is of inestimable value. These essential principles are common to all the other modern so-called **efficiency systems** though they all differ more or less in details of operation, particularly as regards remuneration and the personal element in management.

It should be carefully noted that time and motion study are not essential features of all management. They bear the same relation to *production* that engineering research bears to *design.* They are methods for securing basic data, and if these data are already at hand, time and motion study are not necessary except to extend the data, in exactly the same way that engineering research extends the basis of design. But much high-grade design can be done at present on the basis of the accumulated data now available; and time and motion study will eventually cease to be of so much relative importance in productive processes as the data in all lines accumulate. At present they are of great importance especially in mass production. But, again, care must be exercised that the limitations of their usefulness are observed, otherwise, like too highly developed cost systems,

the cost of the results will be out of all proportion to their usefulness. There are many kinds of work where refined time and motion study, for the sake of determining principles quantitatively, would be an absolute waste of money.

The limitations of functional foremanship or any other system of management employing extended division of labor are, of course, those that have already been discussed in connection with division of labor and coördination in general. Like most refined productive methods they are of greatest value in mass production, or in work involving parts of considerable magnitude. The underlying principles, however, should always be kept in mind in the smallest enterprise and pushed as far as the limitations will allow. It may be of interest to enquire into these limitations a little farther.

It is a well-established principle in manufacturing that the cost of production of any given product tends to decrease as the volume of production increases. This is true partly because general expenses do not increase in proportion to productive costs, hence the unit cost tends to decrease with increased volume. (See Article 74.) But aside from this decrease in cost, which is inherent and automatic, increased volume is, in general, necessary to the extension of division of labor and its attendant economic advantages that tend to reduce unit cost. The economic relations that exist, therefore, between volume and unit cost fix, in a general way, the extent to which division of labor and transfer of skill and thought can be established. As a consequence, it also governs the need of coördinative methods. It is, in fact, the criterion before which these matters must be judged; for no matter how beautiful in theory they may be, they are useless unless they are also of economic value. It will be noted that this applies whether the problem be to reduce the unit cost of a given quantity that is already being produced, or to decrease the unit cost by increasing the quantity that is being produced. In either case the problem is to reduce the number of labor hours per unit of product.

To illustrate, the grocer who can adequately handle all the details of his business, and whose sales are limited by territorial

restriction beyond his control, would not be justified in hiring a porter and a bookkeeper on the sole theory that division of labor would lower his costs. The small repair shop would not be likely to obtain reduced costs by installing a planning system and a routing clerk. Yet nearly all large manufacturing plants have lines of work in which the volume is so small as to constitute a manufacturing problem very much like these simple and obvious examples. If there is volume enough, division of labor may be carried to the limit; but on the other hand, the number of parts produced may be so small that the efforts of one man may supply the demand and division of labor would be useless and result in a financial loss. As a matter of fact, a critical examination of the cost of parts produced in small quantity in factories organized mainly for mass production is more likely to end in the abandonment of these limited fields entirely or, in other words, to result in a further specialization of the factory.

The limiting power of these relations is even more clearly shown where transfer of skill by means of jigs and fixtures is also involved. Where special jigs and fixtures are made for any line of product they should be considered a legitimate part of the cost of the product and their cost should be recovered as soon as possible by distributing it over the cost of a number of machines or other units of product. In very few cases should special tools be carried as an asset. When the article for which they have been made is no longer manufactured such tools become absolutely worthless except for scrap, and their value even as such is very low. Yet this principle is not clearly established in the minds of many manufacturers and the result is often a large accumulation of obsolete tools for which they have paid much money and which is irrecoverable except through sales of product. As an inventory asset they are fictitious, ranking with old patterns and old drawings.

Manufacturing is a *financial* matter; and all productive methods should be judged from this standpoint as well as from the standpoint of mechanical excellence or abstract theories of division of labor and transfer of skill. Thus, it may pay to make a full line of tools and fixtures for the large number of the smaller

sizes of a given product, and division of labor may be economically carried to an extreme; while for the smaller number of the larger sizes of the same line no expenditures for special tools may be justified and extreme division of labor would result in a financial loss. Between these extremes the number and character of the special tools that it will pay to develop will vary, the allowable financial expenditure for special equipment gradually decreasing as the number to be made decreases.

The same remarks apply to the purchase of special machine tools. Shop men, as a rule, can buy standard tools with discrimination where only the *characteristics* of the machine need be considered and its use covers a large range of work. But the purchase of special tools is quite another matter. Such tools are limited in their scope, hence they will pay dividends only when a sufficient quantity of parts suited to them is available. The fact that a special lathe will machine certain parts fifty times as fast as a standard lathe is meaningless unless there are enough of these parts to keep it in operation a sufficient length of time to make the gain by its use more than offset the added interest on the investment. Yet this is not an uncommon source of loss, and the spectacle of high-priced special machinery standing idle a large portion of the time is not infrequent. And the same general theory applies to preplanning of work either in the engineering or production department. It would be foolish, obviously, for a repair shop to make elaborate drawings of small repair jobs on which the work required was self-evident; yet in giving a steamship or a large mill a thorough repairing much planning in both drafting and tool departments might be necessary and economical.

It should be specially noted that this regulative principle, the relation between quantity and unit cost, is often much more definitely known and capable of quantitative application than the other principles already discussed. True, good judgment must always be a large factor in its use; but in the majority of cases the relative gain or loss that will probably occur with change in quantity and method can be computed with sufficient accuracy to make a wise decision probable. The three principal

factors in such changes are, the change in the overhead cost, the increased production, and the added capital investment and the interest thereon. As before stated these factors are in many cases computable with reasonable accuracy.

In a similar manner the number of machines of a given size that it is desirable to manufacture is usually a financial problem that should not, in general, be settled by any one man. (See Article 47.) The amount of money that shall be invested in raw and finished stock and special tools and fixtures may be a critical factor in the life of the business. Yet these and similar problems are often decided off-hand or to suit the ideas of some salesman who is concerned only with quick deliveries and does not see the true financial problem involved in carrying a large investment in raw and finished product and manufacturing tools.

Brief reflection will convince anyone that the application of the relation that exists between quantity and unit cost is a great if not *the* great regulative principle by which to judge the first four principles of this article, which lie at the bottom of all modern efficiency systems so far, at least, as possible financial returns are concerned.

Whether these principles can be economically extended in any specific case will depend on whether the increased output will be obtained at an equal or lower cost. There is, of course, an advantage in increased output at equal cost provided there is a market for the product. Furthermore, each industrial undertaking is a problem by itself. The degree to which the principles of division of labor and transfer of skill may be applied in one place is no criterion whatsoever as to what may be suitable elsewhere. Each case must be judged by the regulative principle discussed above.

It is self-evident, also, that all of these principles become better known quantitatively, and are less personal and empirical in character, as the amount of recorded data bearing on their operation becomes greater. It will be noted in this regard that the basis of the regulative principle (the relation between unit cost and volume) is mathematical and hence quite definite, provided the effect of the changes considered are known. Thus, if the

increase in production, the added investment and the added burden due to an extension of division of labor are known, the application of the regulative principle is quite definite. The exact effects of division of labor, transfer of skill, etc., as has already been noted are not, in general, well known quantitatively. There is, however, a growing interest in the recording of basic data and its systematic use in all lines of industrial work. The *possibility* of successfully planning industrial work rests directly upon the possession of such data. The extent *to which it will pay* to plan work in advance will be governed by the regulative principle of the relation between unit cost and volume of product. This applies, also, with equal truth to the application or extension of any of the economic manufacturing principles discussed in the foregoing paragraphs.

Human Relations.

132. The foregoing discussion of the first six principles of Article 131 has considered them almost entirely as *machinery* of production, and their possibilities and limitations as such. But with the advance in productive machinery there has come a change in the evaluation of the human interests involved that is far more important than these advances themselves. The principles governing human relations permeate every nook and corner of industry, modifying and controlling other factors as never before in the history of the world. They are ever present and cannot for an instant be forgotten or ignored. Until very recently these relations were looked upon as being entirely personal. It was supposed that personality, as expressed in leadership, was the one great force in controlling the relations of men to each other. It is still true and will always remain true that leadership is a prime essential to the success of any enterprise involving human relations, but even here cold, scientific methods have shown that some of these matters can be **measured** and the results recorded, and this has brought new problems into the administration of human affairs.

Thus, it was shown in Article 60 that by means of time-study methods it is possible to measure not only a man's possible out-

put, but also to set the most economical rate at which he can work. By this method the law of **human bodily effort** is removed from the qualitative to the quantitative stage of knowledge and the result of bodily effort becomes a definitely known factor that can be measured and recorded.

Again, motion study has shown that inherited methods of doing work are in many cases most wasteful and can be greatly improved by analytical study. Furthermore, experimental data can here, also, be recorded, thus making it possible to build up synthetically a predicted sequence of operations that is much more efficient than those that come as the result of empirical or inherited methods.

The rewarding of labor, so long a strictly empirical matter, has also been studied analytically, and data showing the ratio of increased reward to increased output are already at hand. Investigations of this character naturally carry the investigator off into psychological measurements of human relations. This field has as yet been barely touched, but what the future holds in store from this form of investigation is difficult to predict, and without doubt the near future will see remarkable developments in the art of measuring factors that affect human relations that now seem intangible.

Many other principles that probably do not admit of quantitative measurement are rapidly becoming a fixed part of all intelligent management. It is now clearly recognized that if men are to put forth their best bodily efforts they must be well fed, well housed and well clothed. Aside from all philanthropic ideas it is found that the physical care of men yields dividends. This thought, however, is comparatively new to many; and not many years ago the employer gave far greater attention to the care of his horses than he did to that of his men. If this is true of bodily effort it is even more true of mental effort. The cost of production does not depend upon the wage rate but upon the *unit wage cost* which is a function of *quantity*; and quantity of output depends on mental and physical strength. It is no secret that the well-fed American can easily outwork most of his foreign competitors. But, as noted in Chapter IV, the caring

for the physical welfare of employees is not an act of charity, and if conducted in any spirit of patronage it is fatal to management.

Of equal importance is the principle that it pays to **teach** men the best methods by which work can be done. This is in strict accord with all human experience; yet the backward state of the educational side of factory management is startling. Even the much lauded old apprenticeship systems were not, as a rule, educational in a true sense. The apprentice was given an *opportunity* to learn by *observation* and *absorption* but was rarely *taught*. Is it any wonder that the accumulated errors and wasteful methods of the trades have persisted? If time and motion study have done no other service than to call attention to this fact they have rendered a good service. It is rapidly becoming recognized that increased refinement in methods and higher requirements for the worker can be met only when coupled with proper methods of instruction. It is not sufficient to set standards that only a few men can reach to the arbitrary exclusion of all others. Every man should be educated industrially to his highest capacity in the work for which he is best fitted, and every man should be given an opportunity to produce to the best of his ability and rewarded accordingly. This implies not only a changed point of view on the part of our public schools, but on the part of factory management also. The work of Mr. H. L. Gantt[1] in training men not only in *skill* but in *habits of industry* is worthy of special attention. The setting of standards of performance means very little, after all, unless these standards are high. And if they are high they can be reached by the majority of workmen only after careful training and preparation.

Now it would seem that all would be benefited by the adoption of all fair means of increasing production. The greater the output per man-hour the greater will be the surplus of production that *may be* distributed to the worker. It has been demonstrated that in the long run increased production does benefit all men. It would, therefore, seem reasonable that the em-

[1] See Work, Wages & Profits, by H. L. Gantt.

ployer should use such scientific data, as he may have, to properly select men, matching the requirements of the position with the characteristics of the man. It would seem that he is justified in measuring, if he can, what a fair day's work should be, and paying only a day's wage for a day's work. There is, in fact, no logical argument against the full use of the analytical or scientific method in attacking any problem in industry. If all men could be brought to realize the economic advantages of this method of attack over empirical and rule-of-thumb methods the standard of production would rise tremendously.

But, on the other hand, it must be recognized by the employer that he can no longer introduce any or all methods into his shop at will. It is a far cry to the days of the Industrial Revolution when the mechanical side of factory equipment could be changed at pleasure and the human portion of the equipment molded to suit the mechanical part. A new industrial day has dawned in which *profits* are not the most important factor. More and more, industry is coming to be looked upon as a *means of supporting human existence* and not as a means of *corporate profit.* The ideal factory so far as producing profits is concerned would be one equipped with the finest of machinery and manned by well-cared for slaves, whose reward was the best of physical care, and the mental training sufficient only for the needs of the industry. This ideal might well have been imagined a few hundred years ago; but such ideals belong to the past, and as industrial ideals have moved farther and farther away from this standard, employers, workmen and more important still, public opinion have become increasingly critical regarding changes in industrial methods. We have become more interested in *men* than in *machines.*

The quickness of the Industrial Revolution and its sudden and disastrous effects upon the workman were possible because of his unprepared condition for self protection. Present-day conditions are vastly different. Labor-saving methods of management differ little in their ultimate economic effect[1] from those of labor-saving machinery. They differ in their applica-

[1] See Chapter III.

tion in that labor-saving or scientific management is much more *personal* in its character, and affects the worker much more intimately. Its principles are also of much more widespread application than those of machine production. There is no business so small or no calling so humble or so high to which this *point of view* is not applicable. Yet its adoption must of necessity be slow as compared with that of the principle of machine production.

Why does the worker naturally resist these new methods? First, because the great majority of men are naturally afraid of all new things that they do not understand and the effects of which they cannot clearly foresee. It is very evident to the worker that time and motion study puts into the hands of the employer a much more powerful *selective* agency than he has hitherto possessed, and the worker is justly afraid of these scientific methods in the hands of the unscientific, the unscrupulous, and the ignorant employer. If this selective power is used solely for the purpose of *sorting* men so as to eliminate the indolent and those that are clearly unfitted for the work in hand, there can be no objection raised against it from the humane standpoint. If, however, it is used to *eliminate all but the very best workers* the effect will be disastrous both from the humane and from the economic standpoint until an entire readjustment of the field has taken place. What is needed is a scheme whereby *every man can be worked up to his full efficiency whether or not his output be as great as that of his neighbor.*

Secondly, the worker may object to these new methods because of his inherent inertia. The workman who has once learned and long practiced certain methods of doing work is seldom willing to admit that better ways may be devised if these ways appear to be radically different from those to which he is accustomed.

And lastly, he naturally opposes these new methods because his own experience and his inherited point of view naturally lead him to suspect any new methods that promise increased remuneration for increased efforts.

The first two objections may, perhaps, be removed by educa-

tional methods but the third is deep-rooted and involves principles that even the advocates of the new methods have not always fully appreciated. The basis of this objection is *distrust* and the root of distrust is most usually *selfishness*, sometimes on the part of the employee but more often on the part of the employer; and this can be removed only when employer and employee can agree as to what is a just and equitable division of the profits of industry; and this involves, not the application of scientific methods to human relations, but the application of the **"fair deal"** on the part of all concerned.

Just what changes shall be made in our political and social structure to make this fair distribution possible does not at present seem clear and prophesies are useless. One thing is clear, however, and that is that such changes are impending; and impending not only because of unrest among workers of the lower grades but because of a changed point of view among the people at large. Mr. Redfield[1] truly says: "It is hard to realize in the ample spaces and broad areas of our land that there are dark industrial places, that men and women, and children also, are confined in foul spots and driven through long hours at pitiful pay for the means not so much of living as existence." Yet this fact *is* being realized more fully every day and the question of increased profits is daily becoming not so much a matter of how large they can be made as it is a question of who is to profit thereby and to what extent. The situation is perfectly logical. It would seem incredible that any nation as intelligent as this, with its educational standard rising steadily, and likely to attain a height hitherto unknown, will not arrive at a solution of the division of the profits of industry that will be fair and just, and will compel all men, willing or unwilling, to abide thereby. Labor-saving management, without doubt, will be much used ultimately because its economic principles are valuable. All such principles that lead to multiplied power of production eventually come into use, though the opposition to them may be very great at first. But labor-saving management will have to justify every one of its features much more fully than did its pro-

[1] See The New Industrial Day, p. 193.

totype labor-saving machinery. It will not be enough that it will increase profits, *it must justify its place in our social economy.*

Economic Results.

133. It is quite obvious that the productive principles discussed in this chapter and elsewhere in this book can be combined into many different systems of management. The general outlines of Mr. Taylor's system, which was the first of the modern systems of so-called scientific management, were discussed briefly in Chapter IX. There have been several other similar systems put forward since, and much has been written on the subject of so-called scientific management. To such an extent is this true that the many descriptions of the machinery of these systems have done much to obscure the principles that lie at the bottom. It has been shown here that these principles are few and comparatively simple. Scientific management is really a point of view that is applicable to the building, equipping and operating of all parts of industrial enterprises and not alone to the work of production in metal-working shops, as one would be led to believe by much of the literature of the subject. It is also applicable to the buying of raw materials and selling of finished product.

Two important claims have been made for these new methods; first, that they will greatly increase production, and second, that they will solve the wage or labor problem. The truth and limitations of the first claim have been fully discussed. It remains to consider very briefly the second claim.

The ground on which advocates of these new, yet old methods, base this second claim is that because of the vastly increased production per man, when using these methods, unit cost will go down and wages will go up. That is to say increased productive power *necessarily* means increased profits and their resulting comforts to the actual producer; for a diligent search through the principles of efficiency engineering fails to disclose any new principles regarding the *distribution* of the fruits of labor. True, great stress is laid on the "square deal" and cooperation of employer and employee in all these systems; but these are not new nor peculiar to any system of management.

It is true, of course, that decreased cost of production always gives the employer an *opportunity* to pay better wages, until his competitors obtain the same methods, when the natural law of competition again comes into effect and the employer is again confronted with the choice of smaller profits, lower wages or still more refined methods and improved tools.

The greatest gain in productive ability that the world has ever witnessed came with the introduction of labor-saving machinery. All the *possibilities* for the physical and mental betterment of humanity offered by the most tremendous gain in productive power mankind has ever witnessed were opened up at that time. The immediate effect of these new methods was to reduce the workers concerned to a state of pauperism and wretchedness which was relieved only by legislation and other reactive measures and not by anything *inherent* in the new methods. These productive methods have been tremendously improved and added to, steadily, for over one hundred years; and what is the net result? Today the skilled mechanic who can save a competence is a rarity. Instead of the individual independence which every man should be able to acquire we are talking of governmental and other forms of pensions. In spite of our much vaunted increased educational facilities only twenty-five per cent of the entire population of this, the most favored of countries, get the minimum amount of education that is considered necessary to make them intelligent citizens. True, the workman of every calling has benefited very greatly by the improved methods, and it is true that he is better clothed, better fed, and better housed, and particularly better educated, than formerly; but the fact remains that his progress has not been proportionate to our increased productive capacity.

Now labor-saving management, as has been shown, does not differ in its action or ultimate effect from that of labor-saving machinery; and while it must be conceded that it will increase production there is no reason for thinking it possesses any inherent power to change the problem of distribution. It was noted in Chapter I that the *total* wealth that any community could possess depended on its natural resources and on the effi-

ciency of its tools of production; but that the *average* wealth was quite another matter, and depended on the method by which the fruits of labor were distributed. Labor-saving management will help to increase the total wealth, but it cannot of itself be expected to do more than labor-saving machinery has done in distributing it.

The great problem that confronts us is not that of production but that of *economic distribution.* We can now produce more manufactured goods than we can use, and far more than is needed to make all of us comfortable. All the new productive processes we may invent will throw little light on the problem of why we find in many places, at the one time, storehouses filled with raw material, idle factories equipped with the finest tools the world has ever seen, and people walking the street without food or clothing, yet willing to work.

The problem is too complex to be solved by the simple expedient of increased production. There still remain the questions of competition, unfair taxation, immigration and a dozen other factors that are not as yet within the control of the employer, be he ever so fair-minded, or of the employee, be he ever so strongly organized. It may be that a readjustment of some of these would do as much for all workers, both employer and employee, as would a large increase of productive power. What is most needed is *scientific distribution.* Fortunate, indeed, will we be if some of the reactive influences now at work on our social and industrial organization will point a peaceful way to this much needed readjustment. Certain it is, however, that no great progress in this direction will be made till workmen are willing to learn forebearance, and employers, setting aside selfishness, will pray as did Plato of old " may my store of gold be such as none but the good can bear."

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